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Capital Flows, Financial Intermediation and Macroprudential Policies

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Abstract

This paper develops an open-economy DSGE model with an optimizing banking sector to assess the role of capital flows, macro-financial linkages, and macroprudential policies in emerging Asia. The key result is that macro-prudential measures can usefully complement monetary policy. Countercyclical macroprudential polices can help reduce macroeconomic volatility and enhance welfare. The results also demonstrate the importance of capital flows and financial stability for business cycle fluctuations as well as the role of supply side financial accelerator effects in the amplification and propagation of shocks.

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I. Introduction

In the wake of the global financial crisis, it is increasingly recognized that central banks have a dual role in maintaining both price and financial stability. A key missing ingredient was an overarching policy framework responsible for systemic financial stability. Neither macroeconomic policymakers nor prudential regulators were in charge of ensuring the stability of the financial system as a whole.[1] One of the discerning features of this crisis has been that shocks originating in credit markets have resulted in a "great recession" and large-scale unemployment. Against this backdrop, there have been increased calls for better understanding macro-financial linkages and the development of a policy that can explicitly focus on system wide risks and macroprudential framework (IMF 2011a).

Managing the macroeconomic stability implications of large capital inflows and build-up of systemic risks is of importance for Emerging Asia.[2] Policymakers face two sets of interrelated challenges: (i) to prevent capital flows from exacerbating macroeconomic overheating pressures and consequent inflation, and (ii) to minimize the risk that prolonged periods of easy financing conditions will undermine financial stability. Given Asia's past experience with credit and/or asset valuation boom-bust cycles, macroprudential measures could be particularly useful in reducing the procyclicality of financial systems and, therefore, the amplitude of business cycles.[3] While debate continues on the appropriate tools and structures for successful mitigation of systemic risk,[4] we consider the policy implications of implementing a macroprudential overlay that could accompany the traditional microprudential and macroeconomic policy. Monetary policy and macroprudential policy are only some aspects of the needed macroeconomic adjustment that a country facing large capital inflows could undertake. The full range of policies in the toolkit for managing capital flows include foreign exchange market intervention, currency appreciation, fiscal adjustment, and structural reforms (see IMF 2011c for a comprehensive discussion).

This paper develops an open economy DSGE model with an optimizing banking sector to assess the role of capital flows, macro-financial linkages, and macroprudential policies in a stylized Emerging Market Economy (EME). It specifically looks at (1) the impact of capital inflows on the economy and credit-asset price cycles; (2) the monetary transmission mechanism in the presence of a banking sector and financial frictions; and (3) the potential role for macroprudential policies in maintaining macro-financial stability including their interactions with monetary policy.

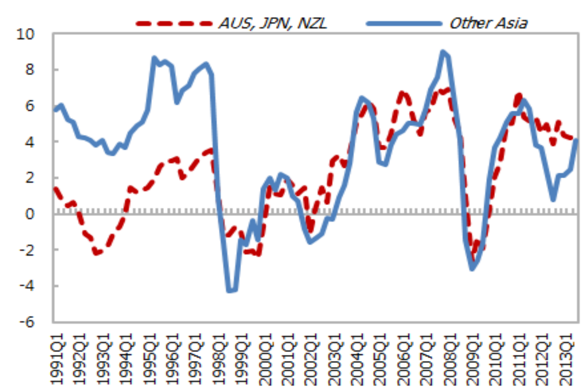
[1] See Viñals (2010).
[2] See Maino and Barnett (2013).
[3] See Craig, Davis, and Pascual (2006) for evidence on the procyclicality of Asian financial markets.
[4] See Bank of International Settlements (BIS henceforth) (2010).

We introduce a banking sector modeled after Gerali and others 2011 augmented with macroprudential policy in the form of capital requirements. Such a set up creates a financial accelerator effect on the supply side of funding where the lending constraint is relaxed when banks' net worth increases. Financial accelerator mechanisms can foster inefficient economic fluctuations (such as excess volatility in lending, investment and output) which can be mitigated by macroprudential policy tools that increase (reduce) the cost to banks of extending (shrinking) credit in good (bad) times.

In such scenario, macroprudential measures can usefully complement monetary policy. Countercyclical macroprudential polices can help reduce macroeconomic volatility and enhance welfare in combination with a modified Taylor rule. The results also demonstrate the importance of capital flows and financial stability for business cycle fluctuations as well as the role of supply-side financial accelerator effects in the amplification and propagation of shocks.

II. Background

Over the past decades capital flows to Emerging Asia have been highly volatile.[5] After a significant surge in the early 1990s, they saw a massive reversal with the Asian financial crisis. Since the mid-2000s, capital flows resumed, but remained volatile, recording a boom from 2006Q4 to 2007Q3, followed by a sharp decline during the Global Financial Crisis (GFC), and another upswing from 2009Q3 to 2011Q3 (Figure 1).



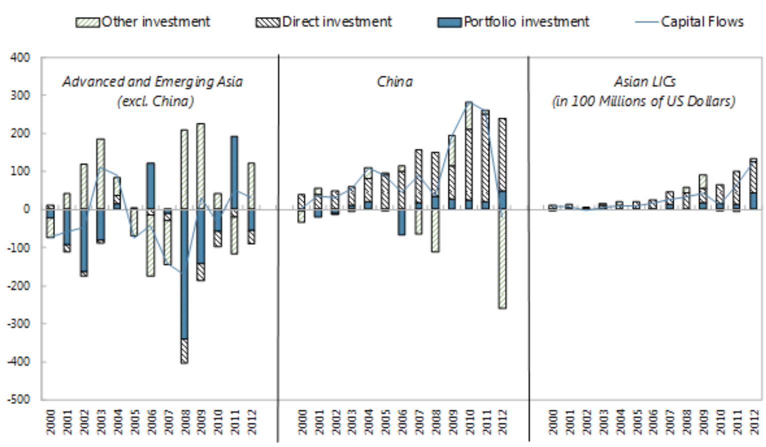
Sources: *International Financial Statistics*; *World Economic Outlook*; and IMF staff calculations.
Other Asia includes China, Hong Kong SAR, India, Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan Province of China, Thailand, and Vietnam.

Figure 1 - Non-Resident Non-FDI Inflows to Asia (Four-quarter moving average)

[5] See the Asian Pacific Regional Economic Outlook (APD-REO henceforth) of April 2011.

After May 2013, in the wake of Fed tapering announcement, portfolio flows saw a sharp reversal. While the pattern of capital flow movements is similar for both industrial Asia (including Australia, Japan, and New Zealand) and the rest of Asia, the latter experienced larger shifts in flows, especially in the 1990s and in 2012-13.

Net capital flows were also volatile, particularly in Asian economies excluding China, also due to their composition. Flows to non-China Asia have been dominated by portfolio and other investment— mainly bank loans (Figure 2). Both are volatile sources of funding: portfolio investment is considered more mobile than other flows, and bank loans are typically short-term. Large portfolio outflows occurred in the aftermath of the GFC, which is a reminiscent of massive outflows in 'other investment category' during the Asian crisis. Both types of flows are also highly sensitive to external financial conditions (see IMF 2011c), particularly in advanced economies: similarly to the most recent ' surge' in inflows, flows to Asia in the run-up to the Asia crisis was related to a declining trend in interest rates in the advanced countries and a search for yield.

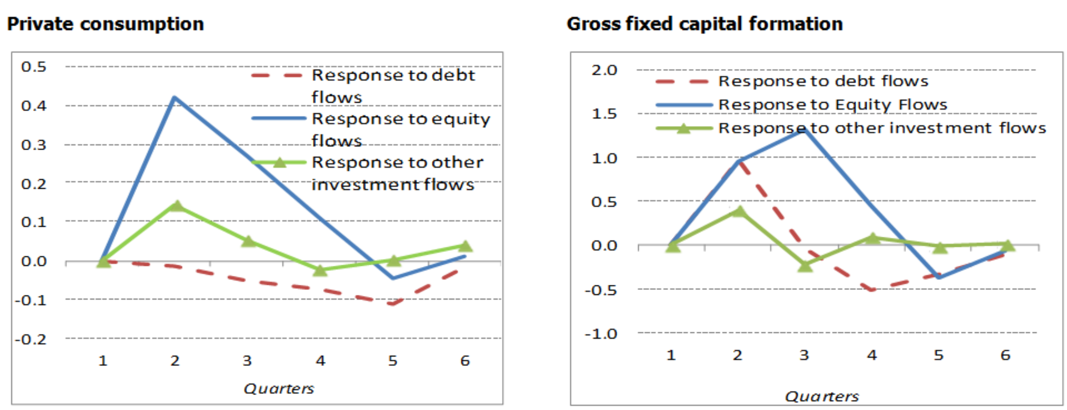


Source: IMF Balance of Payments and IMF staff calculation.

Figure 2 - Asia Capital Flows, Net (in Billions of US Dollars)

As global interest rates are expected to remain low for longer and Emerging Asia will remain a global growth leader, it will very likely continue to receive large capital flows. Nevertheless, a number of global and regional factors will affect interregional and intraregional flows, and most likely, will contribute to capital flow volatility. In the short to medium-term the US Fed exit from unconventional monetary policy and normalization of global interest rates will likely play a role. Bank of Japan's (BoJ) program of quantitative and qualitative monetary easing (QQME) could also potentially have an impact on capital flows to and within the region. Beyond the medium term, capital flows to and within Asia will be largely shaped by capital account liberalization, most notably in China. Other factors, such as financial integration within and outside the region, financial development, and savings patterns—in turn driven by demographics—are also expected to contribute to shape capital flows movements, including within the region. Capital inflows present opportunities, but they can also pose macroeconomic and financial stability risks. The inflows, if channeled effectively, represent an opportunity to address long-standing investment needs, such as in infrastructure. However, capital inflows need to be managed carefully in order to avoid macroeconomic and financial risks. Inflows can increase liquidity and boost domestic demand and asset prices.

In Emerging Asia, the empirical relationship between non-FDI capital inflows and domestic demand is strong (see APD-REO of October 2010). The impulse responses from an unrestricted VAR show that both consumption and investment respond strongly, particularly to equity flows (Figure 3). The effect of a 1 percentage point of GDP increase in equity flows persists for nearly four quarters. At its peak, the effect is equivalent to 0.4 percentage points of quarter-on-quarter annualized growth in the case of consumption, and more than three times that amount for investment. Both components of domestic demand also grow more rapidly following a shock to other investment flows. Finally, investment growth is associated positively with shocks to debt flows, although the effect wears off relatively quickly after two quarters.



Source: IMF staff estimates.

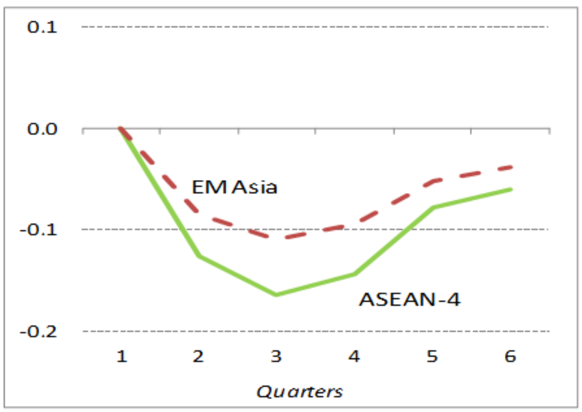
Figure 3 - EM Asia: Response to Increase in Net Capital Infl ows (Response of quarter-on-quarter annualized growth to 1 percentage point of GDP increase in net inflows)

The main channel through which non-FDI capital inflows seems to work in EM Asia is by reducing the cost of equity finance and expanding private credit. The real cost of equity declines following a positive shock to equity infl ows (Figure 4).[6] The effect persists even six quarters

[6]Conceptually, the real cost of equity (i.e., the implied rate of return required by investors) is equal to the sum of the risk-free interest rate and the equity risk premium. At a time of capital inflows, the relative appeal of capital investment increases, making it easier for firms to borrow from banks based on their greater net worth

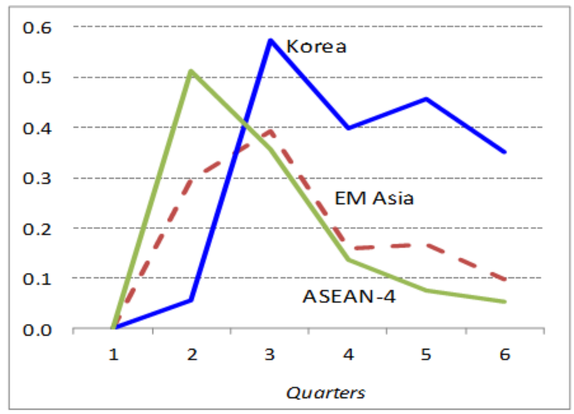
after the initial shock and helps explain why investment growth increases in response to a large inflow of equity capital. Easier external financial conditions enhance the borrowing capacity of corporates and expand the volume of bank resources available to them. Bank credit to the private sector also responds favorably to other investment flows (Figure 5 suggesting that a link between wholesale bank funding from overseas and credit supply.

As banks also rely on wholesale external funding and benefit from lower cost of equity capital, there may also be a tendency to relax lending standards with the easing of external financial conditions.



Source: IMF staff estimates.

Figure 4 - EM Asia: Response of Real Cost of Equity to a 1 percentage Increase in Net Portfolio Equity Flows



Source: IMF staff estimates.

Figure 5 - EM Asia: Response of Credit to Private Sector to a 1 percentage point of GDP Increase in Other Investment Flows

Rapid credit growth raises risks for asset quality and bank capital, particularly once the credit cycle matures. Asia's past history also suggests that high liquidity growth at a time of large capital inflows increases the risk of asset price boom and bust cycles (see the APD-REO of April 2010), which could lead to potential feed-back loops between the corporate/household sector and banks. The APD-REO of October 2011 confirms that episodes of rapid credit growth in Asia have been characterized by a higher incidence of crises relative to other emerging economies.

III. Literature Review

The importance of financial shocks in terms of how they affect the real economy has long been realized but until the 2007 financial crisis most of the general equilibrium models developed to study macro-financial linkages have focused only on the demand side of credit markets. In particular, Kiyotaki and Moore (1997) Bernanke, Gertler and Gilchrist (1999), and Iacoviello (2005), have introduced credit and collateral requirements to analyze the transmission and amplification of financial shocks. These models have abstracted from modeling the banking sector explicitly, and assume that credit transactions take place through the market (thereby not assigning any role to financial intermediaries such as banks). The credit spread that arises in equilibrium (the external finance premium) is a function of the riskiness of the entrepreneurs' investment projects and/or his net wealth. Banks, operating under perfect competition, simply accommodate the changing conditions from the demand side. The growing importance of banks in the modern financial system and the global crisis has demonstrated that the role of financial intermediation cannot be overlooked, and we need to model the supply of credit to understand business cycle fluctuations better. Also, modeling credit supply is essential to study the transmission of shocks originating in the credit markets or financial stability risks.

This paper instead builds on the idea that supply side conditions of credit markets are key to shape business cycle dynamics. In the model, financial frictions affect real activity via the impact of funds available to banks. Other papers such as Anand, Saxegaard, and Peiris (2010), Elekdag and Tchakarov (2007), Gertler, Gilchrist, and Natalucci (2007), Kannan, Rabanal, and Scott (2009), N'Diaye (2009) and Unsal (2013) have a demand-side "financial accelerator" framework but lacks a full-specific banking sector to gauge financial stability and credit supply shocks. The model is a standard New Keynesian open-economy DSGE model with an optimizing banking sector a la Gertler and Karadi (2011) and Gertler and Kiyotaki (2010), and a countercyclical capital requirement as in Angelini et al. (2010). Further details of the model structure are specified in the next section.

This paper takes capital requirements as the choice of macroprudential instrument for two main reasons. First, based on past experience systemic crises inevitably affect bank capital and the supply of credit, either directly or indirectly. And, not surprisingly, bank capital has taken centre stage in the ongoing debate on regulatory reform. The countercyclical capital rule can be viewed as an example of the countercyclical capital buffer introduced by Basel III. Second, countercyclical risk weights and provisioning rates have been used frequently in Asia as a tool of macroprudential policy, which also predominantly works through a bank capital channel.

IV. The Model

The core framework is an open economy model along the lines of Obstfield and Rogoff (1995), Galì and Monacelli (2002) and Gertler et al. (2007). The key modification is the inclusion of a microfounded banking sector as developed by Gertler and Karadi (2011) and Gertler and Kiyotaki (2010). The financial accelerator mechanism in the banking sector links the demand for loans (and therefore for capital) to the balance sheet of banks. As a consequence, a shock in the economy is amplified via the balance sheet of the bank.

In the model there are three players: households, banks and firms. Households work, deposit savings in the banks and consume a basket of home produced and foreign goods and they face financial frictions as in Benigno (2009). The banking sector collects deposits from households, make loans to firms and it faces an agency problem that limits the amount of deposits from households. Firms are divided in capital producers, goods producers and a retailers and their structure is fairly standard. Capital producers produced capital used by goods producers to produce final output. The role of the retail sector is to provide the source of nominal price stickiness.

A. Households

There is a continuum of identical households who consume, save and work. Each household deposit funds in a bank. Deposits take the form of riskless one period securities. Within the households, there is a fraction ϖ of bankers and a fraction $1-\varpi$ of workers. Bankers manages a financial intermediary and transfers non negative dividends to the households. Workers supply labour and return their wages to the households. Bankers remain engaged in their business activity next period with a probability θ which is independent of history. This finite survival scheme is needed to avoid that bankers accumulate enough wealth to remove the funding constraint. Upon exiting, a banker transfers retained earnings to the households and becomes a worker. As a consequence, in each period $(1-\theta)\varpi$ workers become bankers, keeping the number in each group constant. Moreover, each new banker receives a transfer from the household since they cannot start the banking activity without funds.

Consumption Composites. Consumption index C_t consists of home-produced C_H and foreign C_F goods:

$$C_t = \left[\mathrm{w}_C^{\frac{1}{\mu_C}} C_{H,t}^{\frac{\mu_C-1}{\mu_C}} + (1-\mathrm{w}_C)^{\frac{1}{\mu_C}} C_{F,t}^{\frac{\mu_C-1}{\mu_C}} \right]^{\frac{\mu_C}{\mu_C-1}} \tag{1}$$

The corresponding Dixit-Stiglitz price indices is:

$$P_{C,t} = \left[\mathrm{w}_C (P_{H,t})^{1-\mu_C} + (1-\mathrm{w}_C)(P_{F,t})^{1-\mu_C} \right]^{\frac{1}{1-\mu_C}} \tag{2}$$

Standard intra-temporal optimizing decisions for home consumers lead to:

$$C_{H,t} = \mathrm{w}_C \left(\frac{P_{H,t}}{P_{C,t}}\right)^{-\mu_C} C_t \tag{3}$$

$$C_{F,t} = (1-\mathrm{w}_C) \left(\frac{P_{F,t}}{P_{C,t}}\right)^{-\mu_C} C_t \tag{4}$$

The real exchange rate can be defined as the relative aggregate consumption price $RER_{C,t} \equiv \frac{P^*_{C,t}}{P_{C,t}} S_t$ where S_t is the nominal exchange rate. As a consequence, foreign counterparts of the above defining demand for the export of the home goods are

$$C^*_{H,t} = (1-\mathrm{w}^*_C) \left(\frac{P^*_{H,t}}{P^*_{C,t}}\right)^{-\mu^*_C} = (1-\mathrm{w}^*_C) \left(\frac{P_{H,t}}{P_{C,t} RER_{C,t}}\right)^{-\mu^*_C} C^*_t \tag{5}$$

where $P^*_{H,t}$, $P^*_{C,t}$ and $P^*_{I,t}$ denote the price of home consumption, aggregate consumption and aggregate investment goods in foreign currency and we have used the law of one namely $S_t P^*_{H,t} = P_{H,t}$. Again we define

$$P^*_{C,t} = \left[\mathrm{w}^*_C (P^*_{F,t})^{1-\mu^*_C} + (1-\mathrm{w}^*_C)(P^*_{H,t})^{1-\mu^*_C}\right]^{\frac{1}{1-\mu^*_C}} \tag{6}$$

and P^*_I similarly.

As in Benigno (2009) we assume that households face financial frictions when they purchase foreign bonds. There are two non-contingent one-period bonds denominated in the currencies of each block with payments in period t, $B_{H,t}$ and $B^*_{F,t}$ respectively in (per capita) aggregate. The prices of these bonds are given by

$$P_{B,t} = \frac{1}{R_{n,t}}; \qquad P^*_{B,t} = \frac{1}{R^*_{n,t} \phi(\frac{S_t B^*_{F,t}}{P_{H,t} Y_t}) FB_t}$$

where $\phi(\cdot)$ captures the cost in the form of a risk premium for home households to hold foreign bonds, $B^*_{F,t}$ is the aggregate foreign asset position of the economy denominated in home currency and $P_{H,t} Y_t$ is nominal GDP. We assume $\phi(0) = 0$ and $\phi' < 0$. $R_{n,t}$ and $R^*_{n,t}$ denote the nominal interest rate over the interval $[t, t+1]$. The term FL_t represents a term that decreases the risk premium. Since this boosts foreign borrowing, we refer to this disurbance as a foreign borrowing shock that evolves according to the following process:

$$\log\left(\frac{FB_{t+1}}{FB}\right) = \rho_{FL} \log\left(\frac{FB_t}{FB}\right) + \epsilon_{FB,t+1} \tag{7}$$

where $\epsilon_{FB,t}$ is an independet and identically normal distribuited process with zero mean and standard deviation σ_{FB}.

The Household's Decision Problem. The representative household maximizes:

$$E_t \sum_{t=0}^{\infty} \beta \frac{\left[(C_t - \chi C_{t-1})^{(1-\varrho)} L_t^{\varrho} \right]^{1-\sigma} - 1}{1-\sigma} \tag{8}$$

where E_t is the expectation operator indicating expectation formed at time t, β is the discount factor, L_t are hours worked and χ is the consumption habit.

The representative household is subject to the following budget constraint:

$$P_{C,t}C_t + D_t + P_{B,t}B_{H,t} + P^*_{B,t}S_tB^*_{F,t} + TL_t = W_th_t + R_tD_{t-1} + B_{H,t-1} + S_tB^*_{F,t-1} + \Gamma_t$$

where $P_{C,t}$ is a Dixit-Stiglitz price, W_t is the wage rate, TL_t are lump-sum taxes net of transfers and Γ_t are dividends from ownership of firms.

Consumption Allocation and Labour Supply. The intertemporal and labour supply decisions of the household are:

$$P_{B,t} = \beta E_t \left[\frac{\Lambda_{C,t+1}}{\Lambda_{C,t}\Pi_{t+1}} \right] \tag{9}$$

$$P^*_{B,t} = \beta E_t \left[\frac{\Lambda_{C,t+1}S_{t+1}}{\Lambda_{C,t}\Pi_{t+1}S_t} \right] \tag{10}$$

$$\frac{W_t}{P_{C,t}} = \frac{\Lambda_{L,t}}{\Lambda_{C,t}} = -\frac{\Lambda_{h,t}}{\Lambda_{C,t}} \tag{11}$$

where

$$\Lambda_{C,t} = (1-\varrho)C_t^{(1-\varrho)(1-\sigma)-1}(L_t)^{\varrho(1-\sigma)} \tag{12}$$

$$\Lambda_{h,t} = C_t^{(1-\varrho)(1-\sigma)}\varrho(L_t)^{\varrho(1-\sigma)-1} \tag{13}$$

$$\Pi_t \equiv \frac{P_{C,t}}{P_{C,t-1}} \tag{14}$$

B. The Banking Sector

In the model, financial frictions affect real activity via the impact of funds available to banks and there is no friction in transferring funds between banks and nonfinancial firms (see Gertler and Karadi (2011) and Gertler and Kiyotaki. (2011)). Given a certain deposit level a bank can lend frictionlessly to nonfinancial firms against their future profits. In this regard, firms offer to banks a perfect state contingent security.

The level of the loans depends on the level of the deposits D_t, the net worth of the intermediary NW_t. This implies a banking sector's balance sheet of the form:

$$Q_tS_{B,t} = NW_t + D_t \tag{15}$$

where $S_{B,t}$ are claims on non-financial firms to finance capital acquired at the end of period t for use in period $t+1$ and Q_t is the price of a unit of capital so that the assets of the bank. Consequently, $Q_t S_{B,t}$ represents the level of the assets of the financial intermediary.

Net worth of the bank accumulates according to the following law of motion:

$$NW_t = R_{k,t} Q_{t-1} S_{B,t-1} - R_t D_{t-1} \tag{16}$$

Banks exit with probability $1-\theta$ per period and therefore survive for $i-1$ periods and exit in the ith period with probability $(1-\theta)\theta^{i-1}$. Given the fact that bank pays dividends only when it exists, the banker's objective is to maximize expected discounted terminal wealth:

$$V_t = E_t \sum_{i=0}^{\infty} (1-\theta^B)\theta^{B,i} \Lambda_{t,t+i} NW_{t+1+i} \tag{17}$$

subject to an incentive constraint for lenders (households) to be willing to supply funds to the banker.

As in Gertler and Karadi (2011), to motivate an endogenous constraint on the bank's ability to obtain funds, we introduce the following simple agency problem. We assume that after a bank obtains funds, the bank's manager may transfer a fraction of assets to her family. In the recognition of this possibility, households limit the funds they lend to banks. Moreover we assume that the fraction of funds that a banker can divert depends on the composition of the bank's liabilities.

Divertable assets consists of total gross assets $Q_t S_{B,t}$. If a bank diverts assets for its personal gain, it faces defaults on its debt. The creditors may re-claim the remaining fraction $1-\Theta$ of funds. Because its creditors recognize the bank's incentive to divert funds, they will restrict the amount they lend. In this way a borrowing constraint may arise. In order to ensure that bankers do not divert funds the following incentive constraint must hold:

$$V_t \geq \Theta(Q_t S_{B,t}) \tag{18}$$

The incentive constraint states that in order for households to be willing to supply funds to a bank, the bank's franchise value V_t must be at least as large as the gain from diverting funds. As in Gertler and Karadi (2011) and Gertler et al. (2011), to solve the problem we guess a linear solution of the form:

$$V_t = V_t(S_{B,t}, D_t) = \nu_{s,t} S_{B,t} - \nu_{d,t} D_t \tag{19}$$

where $\nu_{s,t}$,and $\nu_{d,t}$, are time-varying parameters that are the marginal values of the asset at the end of period t. Let ϕ_t be the leverage ratio of a bank that satisfy the incentive constraint, from the optimization problem we have that:

$$Q_t S_{B,t} = \phi_t NW_t \tag{20}$$

where ϕ_t represents the leverage ratio. This is equal to:

$$\phi_t = \frac{\nu_{d,t}}{\theta - \left(\mu_{s,t} + x_t \mu_{f,t}\right)} \tag{21}$$

and:

$$\begin{aligned} \nu_{d,t} &= E_t DF_{t,t+1} \Omega_{t+1} R_{t+1} && (22) \\ \mu_{s,t} &= E_t DF_{t,t+1} \Omega_{t+1} (R_{k,t+1} - R_{t+1}) && (23) \end{aligned}$$

where$DF_{t,t+k} = \beta^k \left(\frac{\Lambda_{C,t+1}}{\Lambda_{C,t}}\right)$ is the real stochastic discount rate, Ω_t is the shadow value of a unit of net worth and is equal to:

$$\Omega_t \equiv 1 - \sigma_B + \sigma_B(\nu_{d,t} + \phi_t \mu_t) = 1 - \sigma_B + \sigma\theta\phi_t \tag{24}$$

and the term $R_{k,t+1}$ represents the return on capital defined in the following way:

$$R_{k,t+1} = \frac{E_t \left[Z_{t+1} + (1-\delta)Q_{t+1}\right]}{Q_t} AP_t \tag{25}$$

where Z_{t+1} is the marginal product of capital. The term AP_t represents an asset price shock that evolves according to the following process:

$$\log\left(\frac{AP_{t+1}}{AP}\right) = \rho_{AP} \log\left(\frac{AP_t}{AP}\right) + \epsilon_{AP,t+1}$$

where $\epsilon_{AP,t}$ is an independent and identically normal distribuited process with zero mean and standard deviation σ_{AP}.

Evolution of Aggregate Net Worth At an aggregate level net worth is the sum of existing bankers and new bankers:

$$NW_t = NW_{e,t} + NW_{n,t} \tag{26}$$

Net worth of existing bankers equals earnings on assets held in the previous period net cost of deposit finance, multiplied by a fraction θ, the probability that they survive until the current period:

$$NW_{e,t} = \theta[Z_t + (1-\delta)Q_t]S_{b,t-1} - R_t D_{t-1} \tag{27}$$

Since new bankers cannot operate without any net worth, we assume that the family transfers to each one the fraction $\xi^B/(1-\sigma)$ of the total value assets of exiting entrepreneurs. This implies:

$$NW_{n,t} = \xi^B[Z_t + (1-\delta)Q_t]S_{b,t-1} \tag{28}$$

Given this the aggregate level of net worth is given by:

$$NW_t = \left\{\left(\theta + \xi^B\right)[Z_t + (1-\delta)Q_t]S_{b,t-1} - R_t D_{t-1}\right\} BC_t \tag{29}$$

where BC_t is a shock to bank capital that evolves according to the following process:

$$\log\left(\frac{BC_t}{BC}\right) = \rho_{BC}\log\left(\frac{BC_{t-1}}{BC}\right) + \epsilon_{BC,t} \tag{30}$$

where $\epsilon_{BC,t}$ is an independent and identically normal distribuited process with zero mean and standard deviation σ_{BC}

C. Non-financial Firms

C.1. Goods Producers

Competitive good producers operate a constant return to scale technology with capital an labour as inputs :

$$Y_t^W = (A_t\,(1-L_t))^{\alpha} K_t^{1-\alpha} \tag{31}$$

The term A_t represents a technology shock that follows a process of the form:

$$\log\left(\frac{A_t}{A}\right) = \rho_a \log\left(\frac{A_{t-1}}{A}\right) + \epsilon_{A,t} \tag{32}$$

where $\epsilon_{A,t}$ is an independent and identically normal distribuited process with zero mean and standard deviation σ_A

The firm's behavior is summarized by the following standard first order conditions:

$$\frac{P_t^W}{P_t}\frac{\alpha Y_t^W}{h_t} = \frac{W_t}{P_t} \tag{33}$$

$$\frac{P_t^W}{P_t}\frac{(1-\alpha)Y_t^W}{K_t} = R_t + \delta \tag{34}$$

The final output is then equal to:

$$Y_t = (1-c)Y_i^W \tag{35}$$

where c is a fixed cost of production.

C.2. Capital Producers

Capital producing firms at time t convert I_t of output into $(1-f(X_t))I_t$ of new capital sold at a real price Q_t. They then maximize expected discounted profits

$$E_t \sum_{k=0}^{\infty} DF_{t,t+k}\left[Q_{t+k}(1-f\left(I_{t+k}/I_{t+k-1}\right))I_{t+k} - I_{t+k}\right] \tag{36}$$

This results in the first-order condition

$$Q_tZI_t(1-f(X_t)-X_tf'(X_t))+E_t\left[DF_{t,t+1}\,Q_{t+1}f'(X_{t+1})\frac{I_{t+1}^2}{I_t^2}\right]=1 \tag{37}$$

Up to a first order approximation this is the same as

$$Q_tZI_t(1-f(X_t)-X_tf'(X_t))+E_t\left[\frac{1}{R_{t+1}}Q_{t+1}f'(X_{t+1})\frac{I_{t+1}^2}{I_t^2}\right]=1 \tag{38}$$

We complete this set-up with the following functional form:

$$f(X)=\phi_X\left(\frac{I_t}{I_{t-1}}\right)^2 \tag{39}$$

Investment Composites. Gross investment consists of domestic and foreign final goods:

$$I_t=\left[\mathrm{w}_I^{\frac{1}{\mu_I}}I_{H,t}^{\frac{\mu_I-1}{\mu_I}}+(1-\mathrm{w}_I)^{\frac{1}{\mu_I}}I_{F,t}^{\frac{\mu_I-1}{\mu_I}}\right]^{\frac{\mu_I}{\mu_I-1}} \tag{40}$$

As for the consumption case, the corresponding Dixit-Stiglitz price indices are

$$P_{I,t}=\left[\mathrm{w}_I(P_{H,t})^{1-\mu_I}+(1-\mathrm{w}_I)(P_{F,t})^{1-\mu_I}\right]^{\frac{1}{1-\mu_I}} \tag{41}$$

This delivers the same form of intra-temporal first order conditions:

$$I_{H,t} = \mathrm{w}_I\left(\frac{P_{H,t}}{P_{I,t}}\right)^{-\mu_I}I_t \tag{42}$$

$$I_{F,t} = (1-\mathrm{w}_I)\left(\frac{P_{F,t}}{P_{I,t}}\right)^{-\mu_I}I_t \tag{43}$$

As before if, we define $RER_{I,t}\equiv\frac{P_{I,t}^*S_t}{P_{I,t}}$ for investment, then foreign counterparts of the above defining demand for the export of the home goods are

$$I_{H,t}^*=\mathrm{w}_I^*\left(\frac{P_{H,t}^*}{P_{I,t}^*}\right)^{-\mu_I^*}=\mathrm{w}_I^*\left(\frac{P_{H,t}}{P_{I,t}RER_{I,t}}\right)^{-\mu_I^*}I_t^* \tag{44}$$

where $P_{H,t}^*$, $P_{C,t}^*$ and $P_{I,t}^*$ denote the price of home consumption, aggregate consumption and aggregate investment goods in foreign currency and we have used the law of one namely $S_tP_{H,t}^*=P_{H,t}$. Again we define

$$P_{I,t}^*=\left[\mathrm{w}_I^*(P_{F,t}^*)^{1-\mu_C^*}+(1-\mathrm{w}_I^*)(P_{H,t}^*)^{1-\mu_C^*}\right]^{\frac{1}{1-\mu_C^*}} \tag{45}$$

C.3. The Retail Sector

The retail sector uses a homogeneous wholesale good to produce a basket of differentiated goods for consumption

$$C_t = \left(\int_0^1 C_t(m)^{(\zeta-1)/\zeta} dm \right)^{\zeta/(\zeta-1)} \tag{46}$$

where ζ is the elasticity of substitution. This implies a set of demand equations for each intermediate good m with price $P_t(m)$ of the form

$$C_t(m) = \left(\frac{P_t(m)}{P_t} \right)^{-\zeta} C_t \tag{47}$$

where $P_t = \left[\int_0^1 P_t(m)^{1-\zeta} dm \right]^{\frac{1}{1-\zeta}} P_t$ is the aggregate price index.

Now we assume that there is a probability of $1-\xi$ at each period that the price of each retail good m is set optimally to $P_t^0(m)$. If the price is not re-optimized, then it is held fixed.[7] For each retail producer m the objective is at time t to choose $\{P_t^0(m)\}$ to maximize discounted profits

$$E_t \sum_{k=0}^{\infty} \xi^k DF_{t,t+k} Y_{t+k}(m) \left[P_t^0(m) - P_{t+k} MC_{t+k} \right] \tag{48}$$

subject to (47), where $DF_{t,t+k}$ is the nominal stochastic discount factor over the interval $[t, t+k]$. The solution to this is

$$E_t \sum_{k=0}^{\infty} \xi^k DF_{t,t+k} Y_{t+k}(m) \left[P_t^0(m) - \frac{1}{(1-1/\zeta)} MS_t P_{t+k} MC_{t+k} \right] = 0 \tag{49}$$

and by the law of large numbers the evolution of the price index is given by

$$P_{t+1}^{1-\zeta} = \xi P_t^{1-\zeta} + (1-\xi)(P_{t+1}^0)^{1-\zeta} \tag{50}$$

Defining the nominal discount factor by $DF_{t,t+k} \equiv \beta \frac{\Lambda_{C,t+k}/P_{t+k}}{\Lambda_{C,t}/P_t}$, and the marginal costs $MC_t = \frac{P_t^W}{P_t}$, inflation dynamics are given by

$$H_t - \xi\beta E_t[\Pi_{t+1}^{\zeta-1} H_{t+1}] = Y_t \Lambda_{C,t} \tag{51}$$

$$J_t - \xi\beta E_t[\Pi_{t+1}^{\zeta} J_{t+1}] = \left(\frac{1}{1-\frac{1}{\zeta}} \right) Y_t \Lambda_{C,t} MC_t \tag{52}$$

$$\Pi_t : 1 = \xi \Pi_t^{\zeta-1} + (1-\xi) \left(\frac{J_t}{H_t} \right)^{1-\zeta} \tag{53}$$

[7] Thus we can interpret $\frac{1}{1-\xi}$ as the average duration for which prices are left unchanged.

D. Central Bank

The central bank conducts monetary policy by adjusting the policy rate according to the following Taylor rule:

$$\log \frac{R_{n,t}}{R_n} = \rho_r \log \frac{R_{n,t-1}}{R_n} + (1-\rho_r)(\theta_\pi \log \frac{E_t[\Pi_{t+1}]}{\Pi} + \theta_y \log \frac{Y_t}{Y}) + \epsilon_{r,t+1} \tag{54}$$

where $\epsilon_{r,t+1}$ is a monetary policy shock that is i.i.d. with zero mean and standard deviation σ_M.

The real and the nominal interest rates are linked with the following Fisher equation:

$$R_t = \frac{R_{n,t-1}}{\Pi_t} \tag{55}$$

E. Equilibrium, Foreign Asset Accumulation

Equilibrium and Foreign asset accumulation and the central bank behavior is given by the following equations.

The national income identity is equal to:

$$Y_t = C_{H,t} + I_{H,t} + \frac{1-\nu}{\nu}\left[C^*_{H,t} + I^*_{H,t}\right] + G_t \equiv C_{H,t} + I_{H,t} + EX^*_t + G_t \tag{56}$$

where:

$$EX^*_t = \frac{1-\nu}{\nu}(1-\mathrm{w}^*_C)\left(\frac{P_{H,t}}{P_{C,t}RER_{C,t}}\right)^{-\mu^*_C} C^*_t + \frac{1-\nu}{\nu}(1-\mathrm{w}^*_I)\left(\frac{P_{H,t}}{P_{I,t}RER_{I,t}}\right)^{-\mu^*_I} I^*_t \tag{57}$$

where ν are the share of the foreign economy. Current account dynamics are given by:

$$\frac{1}{R^*_{n,t}\phi(\frac{S_t B^*_{F,t}}{P_{H,t}Y_t})FB_t} S_t B^*_{F,t} = S_t B^*_{F,t-1} + TB_t \tag{58}$$

where the term TB_t represents the trade balance. This is defined as:

$$TB_t = P_{H,t}Y_t - P_{C,t}C_t - P_{I,t}I_t - P_{H,t}G_t \tag{59}$$

The nominal exchange rate:

$$\frac{S_t}{S_{t-1}} = \frac{RER_{C,t}\,\Pi_t}{RER_{C,t-1}\,\Pi^*_t} \tag{60}$$

With local currency pricing the real exchange rate and the terms of trade, defined as the domestic currency relative price of import to export $\mathcal{T}_t = \frac{P_{F,t}}{P_{H,t}}$, are related by the relationships:

$$RER_{C,t} = \frac{\left[\mathrm{w}_C^* + (1-\mathrm{w}_C^*)\mathcal{T}_t^{\mu_C^*-1}\right]^{\frac{1}{1-\mu_C^*}}}{\left[1-\mathrm{w}_C + \mathrm{w}_C\mathcal{T}_t^{\mu_C-1}\right]^{\frac{1}{1-\mu_C}}} \tag{61}$$

$$RER_{I,t} = \frac{\left[\mathrm{w}_I^* + (1-\mathrm{w}_I^*)\mathcal{T}_t^{\mu_I^*-1}\right]^{\frac{1}{1-\mu_I^*}}}{\left[1-\mathrm{w}_I + \mathrm{w}_I\mathcal{T}_t^{\mu_I-1}\right]^{\frac{1}{1-\mu_I}}} \tag{62}$$

Inflation is given by a composite of home and foreign inflation given by the following CES function:

$$\Pi_t = [\mathrm{w}(\Pi_{H,t})^{1-\mu_C} + (1-\mathrm{w})(\Pi_{F,t})^{1-\mu_C}]^{\frac{1}{1-\mu_C}} \tag{63}$$

The foreign Euler equation is:

$$\frac{1}{R_{n,t}^*} = \beta E_t\left[\frac{\Lambda_{C,t+1}^*}{\Lambda_{C,t}^*\Pi_{t+1}^*}\right] \tag{64}$$

Where the nominal interest rate $R_{n,t}^*$ and the real interest rate are linked with the following Fisher equation:

$$R_t^* = \frac{R_{n,t-1}^*}{\Pi_t^*} \tag{65}$$

We close the model with the following autoregressive processes of order one:

$$\log\frac{G_{t+1}}{G} = \rho_G \log\frac{G_t}{G} + \epsilon_{G,t+1} \tag{66}$$

$$\log\frac{MS_{t+1}}{MS} = \rho_{MS} \log\frac{MS_t}{MS} + \epsilon_{MS,t+1} \tag{67}$$

$$\log\frac{R_{n,t-1}^*}{R_n^*} = \rho_R^* \log\frac{R_{n,t-1}^*}{R_n^*} + \epsilon_{R,t+1}^* \tag{68}$$

$$\log\frac{\Pi_{t+1}^*}{\Pi^*} = \rho_\pi^* \log\frac{\Pi_t^*}{\Pi^*} + \epsilon_{\pi,t+1}^* \tag{69}$$

$$\log\frac{C_{t+1}^*}{C^*} = \rho_c^* \log\frac{C_t^*}{C^*} + \epsilon_{c,t+1}^* \tag{70}$$

$$\log\frac{I_{t+1}^*}{I^*} = \rho_I^* \log\frac{I_t^*}{I^*} + \epsilon_{i,t+1}^* \tag{71}$$

$$\log\frac{\Lambda_{t+1}^*}{\Lambda^*} = \rho_\Lambda^* \log\frac{\Lambda_t^*}{\Lambda^*} + \epsilon_{\lambda,t+1}^* \tag{72}$$

V. Macroprudential Policy

Macroprudential policy affects the net worth of existing bankers. As stated before, our aim is to study the impact of capital regulation. To this extend we assume that banks have to pay a penalty when their leverage ratio deviates from a regulatory given target. In such scenario eq. (29) can be represented as:

$$NW_t = \{(\theta + \xi)\left[Z_t + (1-\delta)Q_t\right]S_{b,t} - R_t D_{t-1} - pen * f\left(\frac{NW_t}{Q_t S_{b,t}} - MP_t\right)\}BC_t \tag{73}$$

where $pen * f\left(\frac{NW_t}{Q_t S_t} - MP_t\right)$ represent the penalty of deviating from a given macroprudential target[8]. This represent the capital requirements that the banks face in a form of macroprudential policy. We express MP_t as:

$$MP_t = (1-\rho_{MP})MP + (1-\rho_{MP})(X_t - X) + \rho_{MP} MP_{t-1} \tag{74}$$

we set the steady state level of MP equal to the steady state level of the leverage ratio $\frac{NW_t}{Q_t S_t}$ and the variable X_t equal to the growth rate of output. In this case a positive value of X_t corresponds to a countercyclical policy: capital requirements increase in good times (banks must hold more capital for a given amount of loans) and decrease in recessions. This is in line with the proposed regulatory reform of Basel III. Finally, as in the previous case, BC_t represents a bank capital shock. As before, it evolves according to the following process:

$$\log\left(\frac{BC_t}{BC}\right) = \rho_{BC}\log\left(\frac{BC_{t-1}}{BC}\right) + \epsilon_{BC,t} \tag{75}$$

where $\epsilon_{BC,t}$ is an independent and identically normal distribuited process with zero mean and standard deviation σ_{BC}

VI. Calibration

As far as possible parameters are chosen based on quarterly data and they reflect broad characteristics of emerging asian economies as in Anand et al. (2010) and Batini et al. (2007). In particular, following Anand et al. (2010) we calibrate the great ratios and the shares w_C, w_I, w_C^*, w_I^* at 0.8 and, following Batini et al. (2007) we calibrate the substitution elasticities μ_C, μ_C^* at 1.5 and μ_I, μ_I^* at 0.25. The banking sector is calibrated as in Gertler and Kiyotaki (2010): σ is set at 0.975 implying a survival rate of 10 years. ξ and θ are calibrated to hit an average credit spread of 100 basis points and a financial intermediaries leverage ratio of 4. Table 1 provides the full list of the value of the parameters.

[8]The penality is then collected by the government. However, given the non distortionary nature of this tax it leaves the remaining of the model unaffected.

Table 1 - Calibration

Parameter	Value	Parameter	Value
β	0.99	ϕ_X	2
ξ	0.73	c	0.1429
σ	3	ζ	7.67
$\frac{C}{Y}$	0.70	ϱ	0.17
$\frac{I}{Y}$	0.20	μ_I	0.25
$\frac{G}{Y}$	0.10	μ_I^*	0.25
ρ_A	0.85	μ_C	1.5
ρ_{BC}	0.9	μ_C^*	1.5
ρ_{FB}	0.9	ϕ_B	0.05
ρ_{AP}	0.9	ρ_r^*	0.5
ρ_r	0.5	ρ_π^*	0.5
θ_π	2	ρ_c^*	0.5
θ_y	0.5	ρ_I^*	0.5
α	0.65	ρ_Λ^*	0.5
δ	0.069	σ_B	0.972
w_C	0.8	θ_B	0.384
w_I	0.8	ξ_B	0.004
w_C^*	0.8	pen	0.25
w_I^*	0.8	ρ_{MP}	0.5

VII. The Role of Macroprudential Policy in Reducing Procyclicality

In order to illustrate the role of macroprudential policy in reducing procyclicality we compare the effects of several financial and non-financial shocks of an economy without macroprudential policy with an economy that has a set of active policies to reduce procyclicality. As stated before, we consider five types of shocks: (i) foreign borrowing shock, (ii) bank capital shock, (iii) technology shock, (iv) monetary policy shock and (v) asset price.

The main result we obtain is that macroprudential policy in the form of countercyclical capital regulation is a powerful tool in increasing the resilience of the financial system and the economy as a whole. In all the shocks considered, we register a decrease in the volatility of the banks' capital and therefore in the leverage ratio. This affects the real economy through the amount of lending and consequently the amount of investment. As a consequence, this reduces the volatility in the real economy and it may help to prevent the classic boom and bust cycle.

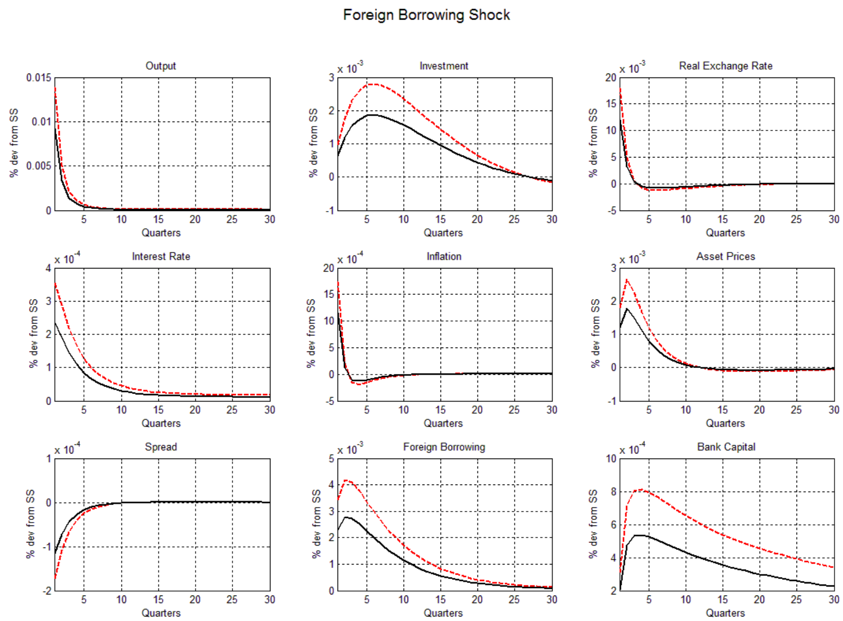


Figure 6 - Impulse response functions to a postive foreign borrowing shock - The red dashed line represents the model without capital regulation and the black line the model with capital regulation.

Figure 6 shows the effects of a shock on foreign borrowing. As expected, the higher foreign borrowing increases the future supply of capital though the investment channel, which in turn responds to an anticipated future rise in profits relative to the cost of funds. The outcome is a higher demand and inflationary pressures, together with a boom in credit growth in the economy following the capital inflow surge. As a consequence, interest rates rise and the real exchange rate appreciates. In the model this mechanism is further amplified since banks are allowed to borrow from abroad therefore there is a financial accelerator mechanism at play. The effects of countercyclical capital regulation are shown in the comparison between the red dashed and the blue line. The mechanism at play is straightforward: an increase in foreign borrowing expands the balance sheet of the banking sector and with a consequent increase of the net worth. Since the capital regulation is modeled after a penalty on the excessive leverage it works to counteract the build up of the intermediary net worth thus reducing the amount of lending and therefore the amount of investment.

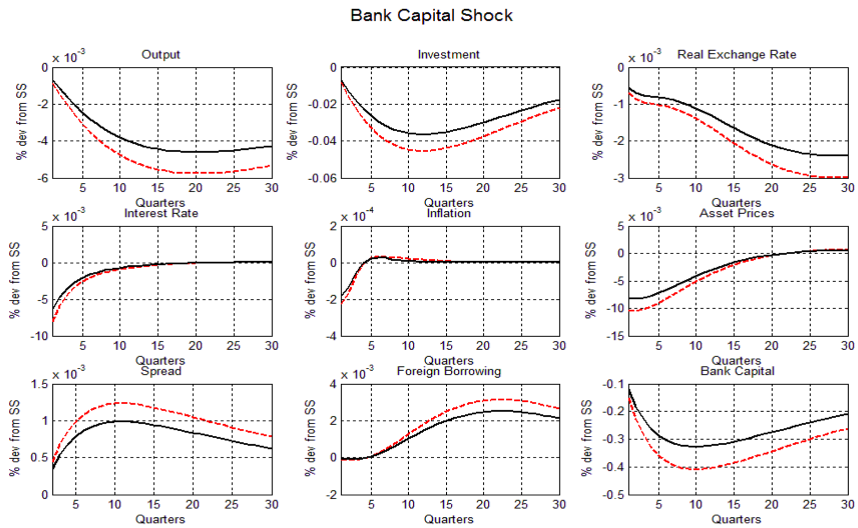


Figure 7 - Impulse response functions to a negative bank capital shock - The red dashed line represents the model without capital regulation and the black line the model with capital regulation.

The response to a bank capital shock is shown in figure 7. As before, it clearly demonstrates the importance of financial stability to business cycle fluctuations as well as the need to account for supply side financial accelerator effects in the amplification and propagation of shocks. The initiating disturbance is an exogenous decline in capital quality or bank capital shock. What we are trying to capture in a simple way is an exogenous force that triggers a decline in the value of intermediary assets such a large non-performing asset. Within the model economy, the initial exogenous decline is then magnified in two ways. First, because banks are leveraged, the effect of a decline in assets values on bank net worth is enhanced by a factor equal to the leverage ratio. Second, the drop in net worth tightens the banks' borrowing constraint inducing effectively a fire sale of assets that further depresses asset values. The crisis then feeds into real activity as the decline in asset values leads to a fall in investment and output.

That transmission mechanism at work during a financial crisis is reflected in the behavior of the spread between the expected return to capital and the riskless interest rate. With financial frictions, the spread rises on impact as a product of the decline in bank net worth. The increase in the cost of capital is responsible for the magnified drop in investment and output. Financial factors also contribute to the slow recovery back to trend. To reduce the spread between the expected return to capital and the riskless rate, bank net worth must increase. So long as the spread is above trend, financial factors are a drag on the real economy. Note that throughout this convergence process, banks are effectively deleveraging since they are building up equity relative to debt. In this way, the model captures how the deleveraging process can slow down a recovery.

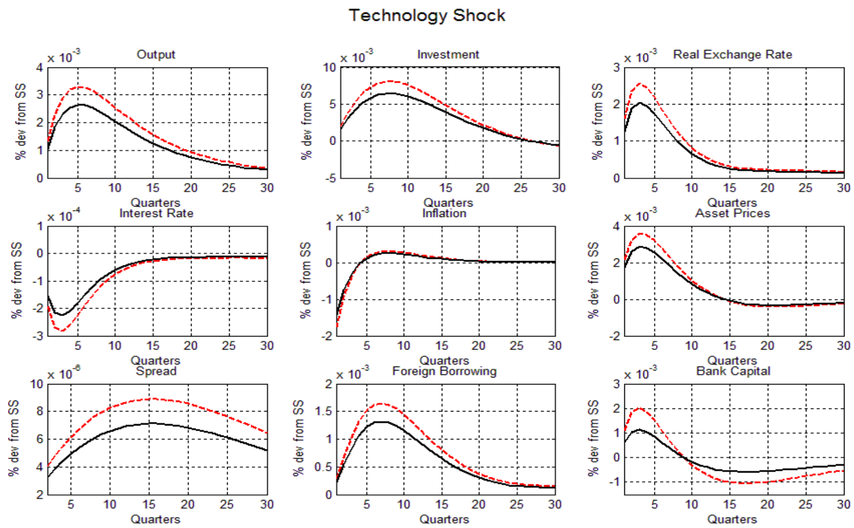


Figure 8 - Impulse response functions to a positive technology shock - The red dashed line represents the model without capital regulation and the black line the model with capital regulation.

Figure 8 shows the result of a technology shock. The dynamics of the economy are similar in response to a foreign borrowing shock, except for inflation which initially falls in response to greater productivity gains. Thus interest rates can be lowered, resulting in a real exchange rate depreciation. Importantly, in both cases a macroprudential or countercyclical capital regulation lowers business cycle fluctuations. However, in the case of a technology shock the capital regulation works against the monetary stance, generating a trade-off between macroeconomic and financial stability objectives.

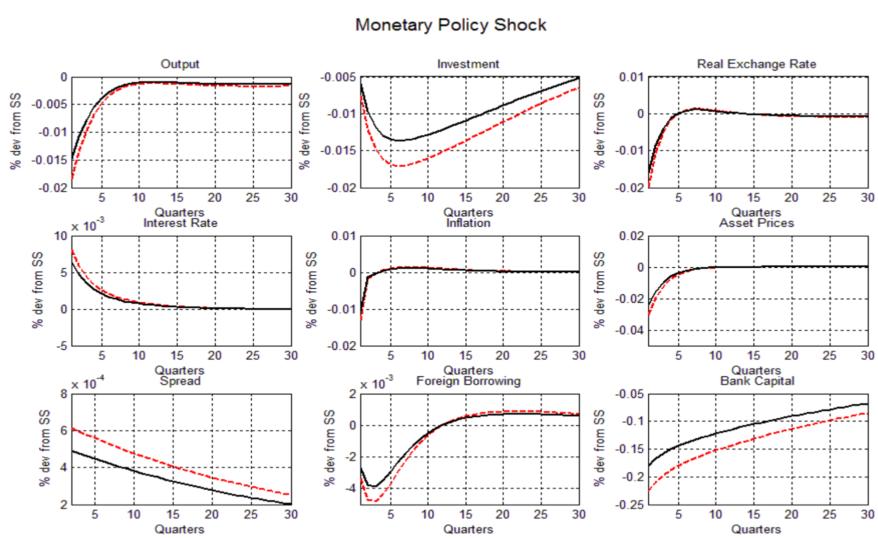


Figure 9 - Impulse response function to a monetary policy tightening - The red dashed line represents the model without capital regulation and the black line the model with capital regulation.

In figure 9 we highlight the impact of monetary tightening. The effect on aggregate demand and inflation will be more moderate with countercyclical capital regulation. A contractionary monetary policy shock reduces asset prices and raises the spread, and thus reduces investment. The lower economic activity reduces inflation and bank profitability. Macroprudential policies will again help reduce procyclicality of the financial system and moderate the fall in investment and inflation.

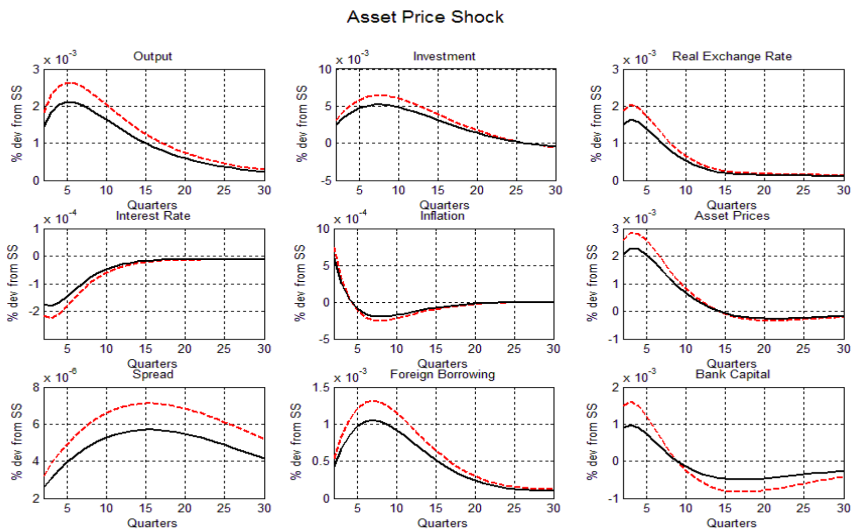


Figure 10 - Impulse response function to an asset price shock - The red dashed line represents the model without capital regulation and the black line the model with capital regulation.

Finally figure 10 shows the effects of a positive asset price shock. we notice that such shock generates a similar impulse response to a technology shock, except that inflation increases in the absence of technology gains necessitating interest rate hikes. This leads to a short-term exchange rate appreciation as expected and classic symptoms of macroeconomic overheating. Also in this case, the macroprudential policy is an effective tool in reducing the volatility of the economy.

VIII. Macroprudential and Monetary Policy Interactions

The interaction of monetary policy with macroprudential policies suggests scope to minimize macrofinancial instability by combining a modified Taylor rule with a macroprudential overlay. In this section we study how macroprudential policy in the form of countercyclical capital regulation interacts with monetary policy.

In order to assess the importance of such interactions, we consider four different policy scenarios. In the first scenario we employ a standard Taylor rule as described in eq. (54). In the second one we modify the Taylor-rule to incorporate a weight on credit growth.[9] This is the same approach used by Christiano et al. (2010), and Curdia and Woodford (2010). In this scenario we want to analyse whether a modified Taylor rule can reduce the welfare loss and hence stabilize the economy. The third scenario aims at showing the importance of macroprudential policy and, to this extent, we introduce the macroprudential framework in the analysis and we use the standard Taylor rule. In the fourth and last scenario we employ the augmented Taylor rule in the macroprudential policy framework. We consider this last case as the reference scenario. Table 2 shows the weights used in the welfare evaluation exercise.

Table 2 - Parameters of the Policy Rule

	Lag interest rate	Inflation Rate	Output Gap	Credit Growth
Taylor Rule	0.5	2.0	0.5	
Taylor Rule with Credit Growth	0.5	2.0	0.5	0.5

To compute the welfare loss in terms of consumption equivalence we employ the methodology as in Schmitt-Grohé and Uribe (2007) and we calculate the welfare loss using a second order approximation of the utility function. This represents the fraction of consumption (in percentage terms) that is required to equate welfare under a given policy rule to the one given by the reference scenario in the face of a one percent given shock.[10] Following Gertler and Karadi (2011) and Unsal (2013) we start by expressing the household utility function in a recursive form:

$$V_t = U\left(C_t, L_t\right) + \beta E_t V_{t+1} \tag{76}$$

Then we take a second order approximation of this function at the steady state. Using the second order solution of the model we calculate the value of V_t for each case. The comparison is made in terms of a consumption equivalent, given by the fraction of consumption required to equate welfare under a given policy to the welfare under the augmented Taylor rule in the macroprudential policy framework. The result is a measure of the welfare loss in units of steady state consumption. A higher value of welfare loss indicates that the policy is less desirable.

In our analysis, unlike Gertler and Karadi (2011) who consider the welfare loss under a single shock (the capital quality shock) and Unsal (2013) who consider only two shocks (technology and a financial shock), we take into account several shocks, namely: (i) borrowing shock, (ii) bank capital shock, (iii) technology shock and (iv) asset price shock.

Table 3 shows the computed welfare losses. The first result that the table highlights is that the augmented Taylor rule in the macroprudential policy framework is the more effective since the welfare loss is positive in all the cases.

[9] Following Unsal (2011) we set the Taylor rule coefficient for credit growth at 0.5.

[10] See Schmitt-Grohe and Uribe (2007) and Faia and Monacelli (2007) for a detailed discussion of the methodology.

Table 3 - Performance of Different Taylor Rules

	Welfare Loss
Foreign Borrowing Shock	
Taylor Rule	0.352
Taylor Rule with Credit Growth	0.268
Taylor Rule and Macroprudential Policy	0.082
Taylor Rule with Credit Growth and Macroprudential Policy	—
Bank Capital Shock	
Taylor Rule	0.434
Taylor Rule with Credit Growth	0.310
Taylor Rule and Macroprudential Policy	0.104
Taylor Rule with Credit Growth and Macroprudential Policy	—
Technology Shock	
Taylor Rule	0.268
Taylor Rule with Credit Growth	0.224
Taylor Rule and Macroprudential Policy	0.072
Taylor Rule with Credit Growth and Macroprudential Policy	—
Asset Price Shock	
Taylor Rule	0.396
Taylor Rule with Credit Growth	0.274
Taylor Rule and Macroprudential Policy	0.094
Taylor Rule with Credit Growth and Macroprudential Policy	—

A second important result is that the welfare loss is higher when financial shocks hit the economy. In particular, the bank capital shock produces the highest welfare loss followed by the asset price shock. In turns, macroprudential policy and, more in general, a stabilizing policy produces the best results for these shocks. For the bank capital shock the difference between the standard Taylor rule scenario and the scenario with an augmented Taylor rule in the macroprudential policy framework is 0.434. Similarly, for the asset price shock, the difference is 0.396. The difference is quite relevant for the foreign borrowing and the technology shock as well but it is not so marked.

Finally, the results suggest that macroprudential policy is more effective than the standard Taylor rule and the Taylor rule augmented with credit growth. This can be seen in the welfare loss difference when macroprudential policy is introduced in the model. As an example we consider the foreign borrowing shock. In terms of welfare the difference between the standard Taylor rule and the augmented Taylor rule is 0.84 (difference between the first and the second line). However, when macroprudential policy is considered the difference becomes 0.270 (difference between the first and the third line). The relatively small role of Taylor rules augmented with credit growth is recorded also when this policy option is included in a framework in which macroprudential policy is present. In this case the welfare loss difference is 0.082. This result applies to all the shocks considered. This implies that, if a central bank wants to mitigate the impact of negative financial and non financial shocks, macroprudential policy is more effective than targeting financial variables in the Taylor rule.

Overall, the results suggest that financial stabilization and in particular, macroprudential measures in the form of capital requirement, play a crucial role in the stabilization policy and especially in the stabilization of financial shocks.

IX. Conclusion

This paper develops an open economy DSGE model with an optimizing banking sector to assess the role of capital flows, macrofinancial linkages, and macroprudential policies. The key result is that macroprudential measures can usefully complement monetary policy in response to most types of exogenous shocks. Countercyclical macroprudential polices can help reduce macroeconomic volatility and enhance welfare in combination with a modified Taylor rule that also places a weight on credit developments. However, the gains from countercyclical macroprudential policies are lower with technology shocks and generally result in lower medium term output. Thus, there is a potential trade-off of using countercyclical capital requirement as proposed in Basel III for emerging markets, requiring a judicial use of macroprudential policies tailored to country circumstances. The results also demonstrate the importance of capital flows and financial stability for business cycle fluctuations as well as supply-side financial accelerator effects in the amplification and propagation of shocks in an emerging Asian economy.

Asset prices and banking lending are the key channels of transmission of capital flows in emerging Asia. The large capital inflows received by emerging Asian countries can result in macroeconomic overheating pressures such as higher inflation and real exchange rate appreciation as well as financial stability risks as capital inflows fuel rapid asset price inflation and credit growth. The results of the DSGE model suggest that the best response to financial and foreign shocks would be to implement countercyclical macroprudential polices as they help reducing macroeconomic volatility and procyclicality of the financial system in combination with a modified Taylor rule that places some weight on credit growth. This seems a more attractive option than contemplating direct measures to control capital inflows and large-scale foreign exchange interventions that have been shown to be suboptimal even in models without optimizing banking sectors (see Unsal 2013 and Berg et al. 2011), although this paper does not consider those policies and leaves that for future research.

Financial instability or shocks to bank capital triggered by a large non-performing loan, for example, has a pervasive and significant impact on the real economy through macrofinancial linkages. The model sheds light on the key transmission mechanism of a financial crisis by showing how bank leverage amplifies the initial shock to capital and tightens the banks' borrowing constraint inducing effectively a fire sale of assets. The crisis then feeds into real activity as the decline in asset values is responsible for the magnified drop in investment and output. In this way the model captures how the deleveraging process can slow down a recovery as observed in the global financial crisis and Asian financial crisis. This transmission mechanism also highlights the importance of maintaining an adequate bank capital buffer, avoiding a rapid growth in credit that often leads to rash of non-performing loans, and role of asset prices in amplifying business cycles. Here again, macroprudential policies could help minimize macrofinancial instability by combining a modified Taylor rule with a countercyclical capital requirement.

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