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Macroprudential Regulation in a DSGE Model of the Philippines with Financial-Real Linkages

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We develop a small open economy New Keynesian DSGE model of financial-real linkages with banking intermediation and macroprudential regulation. The study has two main objectives: (i) understand the role of banking intermediation and financial frictions in the transmission of monetary policy; and (ii) examine the implications of macroprudential regulation of the banking system to the real economy. The results of our research suggest that although the macroprudential tools used by central banks may achieve the goal of safeguarding financial stability of the banking system, it is important to watch out for their effects to the short-run business cycle fluctuations of the real economy.

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The global financial crisis has clearly demonstrated that system-wide disturbances in credit and financial markets pose serious consequences for the real economy, emphasizing the need to go beyond a purely micro-based approach to financial regulation and supervision. Due to the high level of procyclicality in the financial sector, any shocks originating in credit and financial markets could potentially result to macroeconomic instability. In the Philippines, for example, the banking system accounts for almost 80% of the country's overall financial system (Bangko Sentral ng Pilipinas [BSP], 2014). Gross credit registered a tremendous growth of 19% in the first half of 2014, significantly higher than its growth in the same period in 2013 at 11.7%. It is important to watch out for the risks this poses to the price stability and financial stability of the macroeconomy. In response to heightened interests in ensuring a resilient financial system, the BSP has highlighted the need to adopt a macro perspective on financial regulation and supervision. In particular, it has begun taking steps in providing an institutional framework for macroprudential policy geared towards financial stability.

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Several papers have already dealt with macroprudential tools employed by the BSP to achieve financial stability. Albert and Ng (2012) asserted that the capital requirements and additional capital buffers imposed by the BSP among Philippine banks has resulted to adequate bank asset quality and, hence, has improved the banks' balance sheet. Schou-Zibell, Albert, and Song (2012) revealed that capital adequacy correlates positively with liquidity. In particular, domestic credit provided by the banking sector responds positively with capital adequacy. Amat (2012) added that higher levels of banks' nonperforming loans (NPLs) relative to total loans will reflect default risks, hence the need for macroprudential monitoring and assessment. Much of the studies in the literature dealing with macroprudential policy in the Philippines have focused on the effectiveness of such macroprudential tools in mitigating systemic risks in the financial sector and, thus, ensuring financial stability. The other equally important set of research questions that remains to be of considerable interest is the interaction between monetary policy and macroprudential policy. That is, a key issue in designing a framework for macroprudential policy geared towards financial stability is how it interacts with monetary policy aimed to achieve price stability, and thus, how these tools should be coordinated to address both objectives.

Towards the end, this paper develops a small open economy New Keynesian DSGE model of financial-real linkages with banking intermediation and macroprudential regulation. The study has two main objectives: (i) understand the role of banking intermediation and financial frictions in the transmission of monetary policy; and (ii) examine the implications macroprudential regulation of the banking system to the real economy. We introduce financial frictions on both households and entrepreneurs following Iacoviello's (2005) collateral constraints approach and Bernanke, Gertler, and Gilchrist's [BGG] (1999) financial accelerator mechanism, respectively. The model adapts the approach of Christiano, Motto, and Rostagno (2009) [CMR] and Christiano, Trabandt, and Walentin (2011) [CTW] in introducing financial frictions among entrepreneurs in an open-economy setting. CTW follows the financial accelerator framework of BGG. We adapt this treatment of BGG by CTW. On the household side, we model financial frictions using the collateral constraints approach of Iacoviello (2005). We model an active banking sector following Gerali, Stefano, Luca, and Signoretti (2010). Finally we incorporate macroprudential regulation of the banking sector in the form of loan-to-value (LTV) ratio requirement, capital adequacy ratio (CAR) requirement, and time-varying reserve requirements.

THE MODEL

The model adapts the approach of CMR and CTW in introducing financial frictions among entrepreneurs in an open-economy setting. On the household side, we model financial frictions using the collateral constraints approach of Iacoviello (2005). We model an active banking sector following Gerali et al. (2010). Finally we incorporate macroprudential regulation of the banking sector in the form of CAR requirement, LTV ratio requirement, and time-varying reserve requirements.

Households

Savers. Saving households decide the optimal level of consumption of final goods $C_t^p(i)$, labor effort $N_t^p(i)$, housing assets $H_t^p(i)$, and since they are patient, deposits to the bank $D_t(i)$ which pays an interest rate of i_t^d, and net holdings of foreign currency one-period bonds B_{t+1}^f which pays i_t^f interest. They maximize the expected value of discounted sum of utility given by

$$E_0 \sum_{t=0}^{\infty} (\beta_p)^t U\left[C_t^p(i),\ N_t^p(i),\ H_t^p(i)\right] \quad (1)$$

where β_p is the saving households' discount factor. The utility function is specified as

$$U\left[C_t^p(i), N_t^p(i), H_t^p(i)\right] = \varepsilon_t^c (1-a^p) \log\left[C_t^p(i) - a^p C_{t-1}^p\right] - \varepsilon_t^n \frac{N_t^p(i)^{1+\sigma_n}}{1+\sigma_n} + \varepsilon_t^h \frac{H_t^p(i)^{1-\sigma_h}}{1-\sigma_h} \quad (2)$$

where a^p is the group-specific habit formation parameter, ε_t^c and ε_t^n are preference shocks to marginal utility of consumption and labor supply, respectively, and ε_t^h an exogenous shock to housing demand. These shocks are specified as AR(1) processes with independently and identically distributed (i.i.d.) normal disturbances.

Savers have access to foreign financial markets, allowing them to hold foreign currency one-period bonds and receive interest income $S_t B_t^f(i) i_{t-1}^f$, where S_t denotes the nominal exchange rate. They also receive wage income $W_t N_t(i)$ for supplying labor services to the production sector and interest income $i_{t-1}^d P_t D_{t-1}(i)$ from deposits to the bank. The model assumes that saving households own the banks and the final goods firms, hence they receive dividends $\int_0^1 (1-\chi^{bk}) P_t \Pi_{t-1}^{bk}(i) di$ and $\int_0^1 \Pi_t^r(i) di$ from the banks and final goods firms, respectively, where χ^{bk} represents the portion of bank profits used to accumulate bank capital and $\Pi_t^{bk}(i)$ and $\Pi_t^r(i)$ the profits of the ith bank and final goods firm, respectively. Subsequently, they use income to buy and consume final goods, accumulate housing assets, hold foreign currency bonds next period, and save their remaining income to the banks through deposits. Hence, savers face the following budget constraint:

$$P_t C_t^p(i) + P_{H,t}\left[H_t^p(i) - (1-\delta_h) H_{t-1}^p(i)\right] + P_t D_t(i) + S_t B_{t+1}^f(i) = S_t B_t^f(i) i_{t-1}^f + W_t N_t(i) + i_{t-1}^d P_t D_{t-1}(i) + T_t^p \quad (3)$$

where $P_{H,t}$ is the price of housing assets, δ_h the depreciation rate of housing assets, and T_t^p the lump-sum transfers to saving households equal to the sum of bank dividends and dividends from final goods firms. Maximizing the utility function Eq. (2) subject to the budget constraint Eq. (3) yields the optimality conditions for savers' consumption of final goods, labor supply, housing assets, deposits, and holdings of foreign currency bonds (for convenience we omit the i's):

$$\lambda_t^p P_t = \frac{\varepsilon_t^c (1-a^p)}{C_t^p - a^p C_{t-1}^p} \quad (4)$$

$$\lambda_t^p W_t = \varepsilon_t^n N_t^{p\,\sigma_n} \quad (5)$$

$$\lambda_t^p P_{H,t} = \varepsilon_t^h H_t^{p\,\sigma_h} + (1-\delta_h)\beta_p E_t\left[\lambda_{t+1} P_{H,t+1}\right] \quad (6)$$

$$\lambda_t^p P_t = \beta_p E_t \lambda_{t+1} P_{t+1} i_t^d \quad (7)$$

$$\lambda_t^p S_t = \beta_p E_t \lambda_{t+1} S_{t+1} i_t^f. \quad (8)$$

Borrowers. Like saving households, borrowing households decide the optimal level of consumption of final goods $C_t^{im}(i)$, labor effort $N_t^{im}(i)$, and housing assets $H_t^{im}(i)$. Since they are impatient, they value current consumption more than future consumption, hence they spend their income and borrow from the banks in the form of loans $L_t^{im}(i)$. They maximize the expected value of discounted sum of utility given by

$$E_0 \sum_{t=0}^{\infty} (\beta_{im})^t U\left[C_t^{im}(i),\ N_t^{im}(i),\ H_t^{im}(i)\right] \quad (9)$$

where β_{im} is the borrowing households' discount factor and $\beta_{im} < \beta_p$. The utility function is specified as

$$U_t\left[C_t^{im}(i), N_t^{im}(i), H_t^{im}(i)\right] = \varepsilon_t^c (1-a^{im}) \log\left[C_t^{im}(i) - a^{im} C_{t-1}^{im}\right] - \varepsilon_t^n \frac{N_t^{im}(i)^{1+\sigma_n}}{1+\sigma_n} + \varepsilon_t^h \frac{H_t^{im}(i)^{1-\sigma_h}}{1-\sigma_h} \quad (10)$$

where a^{im} is the group-specific habit formation parameter and the other variables are the same as defined in the saving households.

Similar to saving households, borrowing households also receive wage income $W_t N_t^{im}(i)$ for supplying labor services to the production sector. To fund their spending, they borrow from the banks in the form of loan contracts for which they are obliged to pay interest $i_t^{l_{im}}$. Subsequently, they use income to buy and consume final goods, purchase housing assets, and pay interest accrued for the loans to the banks. Hence, the borrowing households face the following budget constraint:

$$P_t C_t^{im}(i) + P_{H,t}\left[H_t^{im}(i) - (1-\delta_h)H_{t-1}^{im}(i)\right] + i_{t-1}^{l_{im}} P_t L_{t-1}^{im}(i) = W_t N_t^{im}(i) + P_t L_t^{im}(i). \quad (11)$$

Following Iacoviello (2005), we introduce a borrowing constraint among borrowing households in the form of a collateral constraint. In particular, we assume that the total loans borrowing households can obtain are limited by the expected value of the collateral (housing assets owned by borrowing households) multiplied by a macroprudential rule, the current LTV ratio LTV_t for mortgages:

$$i_t^{l_{im}} P_t L_t^{im}(i) \le LTV_t E_t\left[P_{H,t+1}(1-\delta_h)H_t^{im}(i)\right] \quad (12)$$

The value of LTV_t determines the amount of loans that banks provide to borrowing households for a given discounted value of their housing stock. The introduction of collateral constraints on borrowing households allows us to examine the implications of credit-supply restrictions for the real side of the economy. The collateral constraint creates a link between credit markets and the real side of the economy. In particular, when the economy experiences an expansionary phase, price of housing assets owned by borrowing households tend to rise, which in turn increases their borrowing capacity and credit worthiness. Hence, demand for loans expands and this boosts consumption, which in turn pushes further the expansion of the economy.

In addition, collateral constraints allow us to study the mechanism of varying LTV_t as a form of macroprudential regulation. The LTV ratio determines the loanable value of borrowers' assets used as collateral for bank loans. Banking supervision authorities set the maximum level of LTV ratio to reduce loan concentration risk and bank exposure to specific sectors of the economy.[2]

Maximizing borrowing households' utility in Eq. (10) subject to the budget constraint in Eq. (11) and collateral constraint in Eq. (12) yields the optimality conditions for consumption of final goods, labor supply, housing assets, and loans (for convenience we omit the i's):

$$\lambda_t^{im} P_t = \frac{\varepsilon_t^c(1-a^{im})}{C_t^{im} - a^{im}C_{t-1}^{im}} \quad (13)$$

$$\lambda_t^{im} W_t = \varepsilon_t^l N_t^{im}(i)^{\sigma_n} \quad (14)$$

$$\lambda_t^{im} P_{H,t} = \varepsilon_t^h H_t^{im}(i)^{\sigma_h} + (1-\delta_h) E_t\left[\beta_{im}\lambda_{t+1}P_{H,t+1} + \mu_t LTV_t P_{H,t+1}\right] \quad (15)$$

$$\lambda_t^{im} P_t = \mu_t P_t i_t^{l_{im}} + \beta_{im} E_t \lambda_{t+1} P_{t+1} i_t^{l_{im}}. \quad (16)$$

Entrepreneurs

As mentioned, we adapt the BGG treatment of CMR and CTW in introducing financial frictions among entrepreneurs in an open-economy setting. We assume that the presence of asymmetric information between lenders (banks) and borrowers (entrepreneurs). The amount that banks are willing to lend to an entrepreneur under a debt contract is a function of the entrepreneur's net worth, hence ultimately of the balance sheet of the firm. Following CMR and CTW, this is how constraints in the balance sheet of entrepreneurs enter the model.[3] We depart from CMR and CTW by assuming that entrepreneurs have access to foreign financial markets, hence part of their total borrowing consists of loans raised abroad.

The individual entrepreneur. At the end of period t each entrepreneur has a level of net worth, NW_{t+1}. Total borrowing of the entrepreneur satisfies the following condition:

$$B_{t+1}^{e} = P_{k',t}\overline{K}_{t+1} - NW_{t+1} \tag{17}$$

where $P_{k',t}$ is Tobin's q, the real price per unit of capital. A proportion of total borrowing $\alpha_e B_t^e = L_t^e$ comes from domestic banks and the remaining proportion $(1-\alpha_e)B_t^e = L_t^f$ comes from external sources in the form of loans raised abroad. Both proportions are assumed to be exogenously given. The entrepreneur is obliged to pay an interest rate $i_{t+1}^{l_e}$ and i_{t+1}^{f} on the domestic and foreign bank loans, respectively, at the end of period $t+1$, if it is feasible to do so.

The entrepreneur faces an idiosyncratic productivity shock after purchasing capital. The idiosyncratic shock converts the purchased capital $\overline{K}_{t+1}$ into $\overline{K}_{t+1}\omega$, where ω is a unit mean, lognormally and independently distributed random variable across entrepreneurs and with variance σ_t^2. The cumulative distribution function of ω is given by $F(\omega;\sigma)$ and its partial derivatives with respect to ω and σ are $F_\omega(\omega;\sigma)$ and $F_\sigma(\omega;\sigma)$, respectively.

We assume that after observing period $t+1$ shocks, the entrepreneurs sells the undepreciated portion of physical capital to capital producers in a perfectly competitive environment. Per unit of physical capital purchased, the entrepreneur with an idiosyncratic productivity shock ω earns a return $R_{t+1}^k\omega$ net of taxes, where R_{t+1}^k is the rate of return on a period t investment in a unit of physical capital given by

$$R_{t+1}^{k} = (1-\tau_t^k)E_t\left[\frac{r_{t+1}^k P_{t+1} + (1-\delta_k)P_{t+1}P_{k',t+1} + \tau_t^k \delta P_t P_{k',t}}{P_t P_{k',t}}\right] \tag{18}$$

where $R_{t+1}^k = E_t\left(1+r_{t+1}^k\right)$, r_{t+1}^k is the marginal productivity of capital, τ_t^k tax rate on the return on capital, and δ_k the depreciation rate of capital. Because ω is a unit mean random variable, R_{t+1}^k is the average return across all entrepreneurs.

After they sell their capital, entrepreneurs settle their bank loans. The real cost of domestic loan contracts is given by $\alpha_e E_t\left[\frac{i_t^{l_e}}{\pi_{t+1}}\right]$, where $\pi_{t+1} = \frac{P_{t+1}}{P_t}$ is domestic CPI inflation. On other hand, the real cost of foreign loans is given by $(1-\alpha_e)E_t\left[\frac{i_t^f}{\pi_{t+1}^*}\frac{S_{t+1}}{S_t}\right]$, where $\pi_{t+1}^* = \frac{P_{t+1}^*}{P_t^*}$ is foreign inflation. The total available resources for an entrepreneur who has purchased $\overline{K}_{t+1}$ units of physical capital in period t and who faces an idiosyncratic productivity shock ω at this point is given by $P_t P_{k',t} R_{t+1}^k \omega \overline{K}_{t+1}$. Following CMR and CTW, we assume that there is a cutoff value of ω, $\overline{\omega}_{t+1}$, such that the entrepreneur has just enough resources to settle interest payments of loans:

$$P_t P_{k',t} R_{t+1}^k \omega \overline{K}_{t+1} = \widetilde{Z}_{t+1} B_{t+1}^e \tag{19}$$

where $\widetilde{Z}_{t+1} = \left\{\alpha_e E_t\left[\frac{i_t^{l_e}}{\pi_{t+1}}\right] + (1-\alpha_e)E_t\left[\frac{i_t^f}{\pi_{t+1}^*}\frac{S_{t+1}}{S_t}\right]\right\}$. We associate bankrupt entrepreneurs to those who fail to meet the cutoff value, that is, $\omega < \overline{\omega}_{t+1}$. Bankrupt entrepreneurs turn over all their resources $P_t P_{k',t} R_{t+1}^k \omega \overline{K}_{t+1}$, which is less than the cost of total borrowing. In this case the monitoring cost of the bank is given by

$$MC_t^{bk} = \mu P_t P_{k',t} R_{t+1}^k \omega \overline{K}_{t+1} \tag{20}$$

where $\mu \geq 0$ is the monitoring cost parameter.

Aggregation across entrepreneurs and the external finance premium. The law of motion for the net worth of an individual entrepreneur is given by:

$$V_t = P_{t-1}P_{k',t-1}R_t^k \overline{K}_t - J_t B_{t-1}^e. \tag{21}$$

where J_t is the entrepreneur's marginal external financing cost. Each entrepreneur faces an identical and independent probabilities ω_t of surviving until the next period and $1-\omega_t$ of exiting the economy. The selection is random, hence the net worth of surviving entrepreneurs is simply $\omega_t V_t$. A fraction $1-\omega_t$ of entrepreneurs enters into the economy, and we assume that newly entering entrepreneurs receive a transfer, W_t^e. Hence, the law of motion of the aggregate (average) entrepreneurial net worth is given by:

$$\overline{N}W_{t+1} = \omega_t \overline{V}_t + W_t^e. \tag{22}$$

The consumption of entrepreneurs is given by:

$$\overline{C}_t^e = (1-\omega_t)(\overline{V}_t - W_t^e). \tag{23}$$

We assume the presence of asymmetric information between the lenders (banks) who provide the loans and the borrowers (entrepreneurs) who use the loans to finance capital. This information asymmetry then generates a principal-agent problem, which results in an external finance premium defined as the difference between the cost of borrowing from banks and the cost of using internal funds (entrepreneur's net worth). The premium depends on the net worth of the entrepreneur and determines the amount of loans that can be approved. Thus, the entrepreneur's marginal external financing cost $E_t J_{t+1}$ is the product of the external finance premium $f\left(\frac{NW_{t+1}}{P_{k',t}\overline{K}_{t+1}}\right)$ and the real opportunity cost of funds:

$$E_t J_{t+1} = (1+\varepsilon_t^f) f\left(\frac{NW_{t+1}}{P_{k',t}\overline{K}_{t+1}}\right)\left\{\alpha_e E_t\left[\frac{i_t^{l_e}}{\pi_{t+1}}\right] + (1-\alpha_e)E_t\left[\frac{i_t^f}{\pi_{t+1}^*}\frac{S_{t+1}}{S_t}\right]\right\} \tag{24}$$

where ε_t^f is a shock to entrepreneur's marginal cost of borrowing. Again, we invoke the assumptions made in BGG and CTW to permit us to express the external finance premium as a function of the aggregate leverage ratio, and hence aggregate entrepreneurial net worth. This implies that the external finance premium is not entrepreneur-specific.

Entrepreneur's demand for capital depends on both the expected marginal return on capital and the expected marginal cost of borrowing to finance an additional unit of capital. Therefore, the demand for capital satisfies the optimality condition $E_t J_{t+1} = R_{t+1}^k$:

$$(1+\varepsilon_t^f) f\left(\frac{NW_{t+1}}{P_{k',t}\overline{K}_{t+1}}\right)\left\{\alpha_e E_t\left[\frac{i_t^{l_e}}{\pi_{t+1}}\right] + (1-\alpha_e)E_t\left[\frac{i_t^f}{\pi_{t+1}^*}\frac{S_{t+1}}{S_t}\right]\right\}$$

$$= (1-\tau_t^k)E_t\left[\frac{r_{t+1}^k P_{t+1} + (1-\delta_k)P_{t+1}P_{k',t+1} + \tau_t^k \delta P_t P_{k',t}}{P_t P_{k',t}}\right]. \tag{25}$$

Final Goods Producers

Final goods producers purchase intermediate goods Q_t^e from entrepreneurs at price P_t^e and differentiate, that is, brand them at no cost to produce final domestic goods Q_t^d and export goods Q_t^x, which they sell in a monopolistically competitive domestic and export markets, respectively. That is, final goods firms sell the goods at a markup over the price P_t^e. Final domestic goods is a constant elasticity of substitution (CES) composite of individual intermediate goods:

$$Q_t^d = \left[\int_0^1 Q_t^d(i)^{\frac{\vartheta_{d,t}-1}{\vartheta_{d,t}}} di\right]^{\frac{\vartheta_{d,t}}{\vartheta_{d,t}-1}} \tag{26}$$

where $\vartheta_{d,t}$ is the elasticity of substitution among varieties of final domestic goods. As will be shown later, $\vartheta_{d,t}$ is also the time-varying markup charged by final goods firms. It follows an AR(1) process with i.i.d. normal disturbances. The price of the final domestic good is derived by minimizing the cost of final domestic goods production:

$$P_t^d = \left[\int_0^1 P_t^d(j)^{1-\vartheta_{d,t}} dj\right]^{\frac{1}{1-\vartheta_{d,t}}}. \tag{27}$$

Solving the profit maximization problem of the final domestic goods firm yields the demand function for final domestic goods:

$$Q_t^d(i) = \left[\frac{P_t^d(i)}{P_t^d}\right]^{-\vartheta_{d,t}} Q_t^d. \tag{28}$$

The demand for export goods is derived in the same fashion and is given by:

$$Q_t^x = \left(\frac{P_t^x}{P_t^*}\right)^{-\vartheta_{x,t}} \tag{29}$$

where $P_t^x = S_t P_t^d$ is the price of exports, P_t^* is the foreign CPI and $\vartheta_{x,t}$ denotes the price elasticity of exports which is also the time-varying markup on export goods.

We allow for nominal rigidities in final goods production in the form of sluggish price adjustment (i.e. sticky prices) by final goods producers. We use the framework of Ireland (2001, 2003) and Rotemberg (1982) in introducing sticky prices in final goods production. We assume that final goods firms face the following quadratic adjustment cost Φ_t^r when they set the price of domestic final goods:

$$\Phi_t^r = \frac{\phi_d}{2}\left(\frac{\pi_t^d}{\pi^s} - 1\right)^2 Y_t \tag{30}$$

where ϕ_d represents the cost adjustment parameter for the final goods firm, π_t^d the domestic price inflation, π^s the steady state inflation, and $Y_t = Q_t^d + Q_t^x$ denotes total production of final goods. Final goods producers maximize real profits by:

$$\Pi_t^r = \left\{\left[\frac{P_t^d(i)}{P_t} - \frac{MC_t^e}{P_t}\right]\left[\frac{P_t^d(i)}{P_t^d}\right]^{-\vartheta_{d,t}} - \Phi_t^r\right\} Y_t \tag{31}$$

subject to the price adjustment cost Φ_t^r in Eq. (30). Solving this profit maximization problem yields the optimal price-setting for final goods firms, which also gives rise to the New Keynesian Phillips Curve (NKPC) of the model:

$$P_t^d = \frac{\vartheta_{d,t}}{\vartheta_{d,t}-1} MC_t^e - \frac{\phi_d}{\vartheta_{d,t}-1} P_t \left\{ \frac{\pi_t^d}{\pi^{ss}}\left(\frac{\pi_t^d}{\pi^{ss}} - 1\right) + \beta_p E_t\left[\frac{C_t^p - a^p C_{t-1}}{C_{t+1}^p - a^p C_t}\left(\frac{\pi_{t+1}^d}{\pi^{ss}} - 1\right)\frac{\pi_{t+1}^d}{\pi^{ss}}\frac{Q_{t+1}^d}{Q_t^d}\right]\right\} \tag{32}$$

where we have invoked symmetry in equilibrium as well as the law of one price in the export goods market.

Capital Goods and Housing Producers

The introduction of capital goods and housing producers provide the microfoundations for the market price of capital goods and housing, both of which are used to determine the value of entrepreneurs' leverage ratio and borrowing households' collateral which banks consider when they provide loans to these borrowers.

At the beginning of each period, each capital and housing producer purchases an amount $I_t(i)$ of final good from final goods firms. We assume that the aggregate investment good is a CES composite of domestic and imported final goods:

$$I_t(i) = \left[\gamma^{\frac{1}{\vartheta}}\left(I_t^d(i)\right)^{\frac{\vartheta-1}{\vartheta}} + (1-\gamma)^{\frac{1}{\vartheta}}(I_t^f(i))^{\frac{\vartheta-1}{\vartheta}}\right]^{\frac{\vartheta}{\vartheta-1}}. \tag{33}$$

Maximizing Eq. (33) yields the optimal demand for domestic and imported investment goods given by:

$$I_t^d(i) = \gamma\left(\frac{P_t^d}{P_t}\right)^{-\vartheta} I_t(i) \tag{34}$$

$$I_t^f(i) = (1-\gamma)\left(\frac{P_t^f}{P_t}\right)^{-\vartheta} I_t(i) \tag{35}$$

where we assumed that the price of aggregate investment is the overall CPI.

Capital producers also purchase the stock of old undepreciated capital $(1-\delta_k)\overline{K}_{t-1}$ from entrepreneurs. They combine the stock of old undepreciated capital leased from entrepreneurs with existing capital stock to transform gross investment $I_t(i)$ into new capital.[4] We assume that old capital can be transformed one-to-one into new capital. However, in the transformation of the final good $I_t(i)$ into new capital, we assume that capital producers pay a quadratic adjustment cost Φ_t^k given by:

$$\Phi_t^k = \frac{\phi_k}{2}\left[\frac{I_t(i)}{\overline{K}_t(i)} - \delta_k\right]^2 \overline{K}_t(i) \tag{36}$$

where ϕ_k is the cost adjustment parameter for the capital producer. This allows us to model nominal rigidities in new capital goods production in the form of sluggish capital stock adjustment. Hence, the law of motion of (aggregate) new capital is given by:

$$\overline{K}_{t+1} = (1-\delta_k)\overline{K}_t + \varepsilon_t^I I_t - \Phi_t^k \tag{37}$$

where $\varepsilon_t^{I_K}$ is a shock to the marginal efficiency of investment á la Greenwood, Hercowitz, and Krusell (1997). We assume that it follows an AR(1) process. Expected profits of capital producers is given by:

$$E_t\left[P_{k',t}\left(\varepsilon_t^I I_t - \Phi_t^k\right) - I_t\right] \tag{38}$$

Solving the capital producer's profit maximization problem determines the real price of physical capital $P_{k',t}$, that is, Tobin's q:

$$1 = P_{k',t}\left[\varepsilon_t^{I_K} - \phi_k\left(\frac{I_t}{\overline{K}_t} - \delta_k\right)\right] \tag{39}$$

Housing producers behave in the same way as capital producers in producing new housing assets. They face a quadratic adjustment cost Φ_t^h given by:

$$\Phi_t^h = \frac{\phi_h}{2}\left(\frac{I_t}{H_t} - \delta_h\right)^2 H_t \tag{40}$$

where ϕ_h denotes the adjustment cost parameter for housing producers. The law of motion of aggregate housing stock is given by:

$$H_{t+1} = (1-\delta_h)H_t + \varepsilon_t^I I_t - \Phi_t^h. \tag{41}$$

Housing producers maximize expected profits

$$E_t\left[P_{H,t}\left(\varepsilon_t^I I_t^H - \Phi_t^h\right) - I_t\right] \tag{42}$$

so that the optimal supply of housing assets determines the real price of housing assets given by:

$$1 = P_{H,t}\left[\varepsilon_t^I - \phi_h\left(\frac{I_t}{H_t} - \delta_h\right)\right]. \tag{43}$$

Banking Sector

As previously mentioned, we adapt the approach of Gerali et al. (2010) in explicitly modeling the banking sector. Banks intermediate all financial transactions between agents, hence they play a central role in the model. Two types of financial instruments are created by banks: deposit contracts issued to saving households and loan contracts offered to borrowing households and entrepreneurs.

We introduce bank capitalization channel in the model. Banks obey the balance sheet identity:

$$L_t(i) = \widetilde{D}_t(i) + BK_t(i) \tag{44}$$

where $L_t(i) = L_t^{im} + L_t^e$ is the total loans in the assets side of the banks' balance sheet, and on the liabilities side, $\widetilde{D}_t(i) = (1 - RR_t - \alpha^T)D_t(i)$ is the remaining available deposits after accounting for reserve requirements RR_t and government securities α^T (which earns T-bill rate i_t^T), and BK_t bank capital. The balance sheet identity above implies that banks can finance their loans using either total deposits net of the reserve requirements or bank capital. We assume that bank capital is accumulated out of retained earnings. In the banks' perspective, the two sources of loan finance are perfect substitutes. In order to pin down the choices of the bank, we follow Gerali et al. (2010) in introducing imperfect substitutability in the form of an exogenously given "optimal" capital-to-assets ratio for banks. This allows us to model another important macroprudential measure, the CAR requirement.

Each bank i is divided in two levels: the wholesale and retail branches. The wholesale branch creates and collects wholesale loans and wholesale deposits, respectively. It also manages the bank's capital position as well as its activities at the interbank market. The retail branch collects deposits from saving households and provides loans to borrowing households and entrepreneurs.

Loan and deposit demand. Each unit of deposit and loan contracts is modeled in a similar fashion as the Dixit-Stiglitz framework in goods market. Hence, in this credit market model, households and entrepreneurs purchase deposit (loan) contracts from each single bank in order to save (borrow) one unit of resources. We assume that units of deposit and loan contracts purchased by households and entrepreneurs are a composite CES basket of slightly differentiated products each supplied by a branch of bank i.

The aggregate saving households' demand for deposits at bank i is given by:

$$D_t(i) = \left[\frac{i_t^d(i)}{i_t^d}\right]^{-\vartheta_{dep,t}} D_t \qquad (45)$$

Aggregate borrowing households' demand for loans at bank i is given by:

$$L_t^{im}(i) = \left[\frac{i_t^{l_{im}}(i)}{i_t^{l_{im}}}\right]^{-\vartheta_{l_{im},t}} L_t^{im} \qquad (46)$$

The demand for entrepreneurs' loan is obtained analogously and is given by:

$$L_t^e(i) = \left[\frac{i_t^{l_e}(i)}{i_t^{l_e}}\right]^{-\vartheta_{l_e,t}} L_t^e \qquad (47)$$

Wholesale branch. The wholesale branch creates wholesale loans and passes them to the lending bank at the retail branch which it charges interest rate of $i_t^{w_l}$. To create wholesale deposits, it collects household deposits from the savings bank at the retail level which it pays an interest rate of $i_t^{w_d}$. The wholesale bank obeys the balance sheet identity in Eq. (44) in creating wholesale loans. To assess the implications of the macroprudential rule CAR, we assume that the wholesale branch faces a quadratic adjustment cost Φ_t^{BK} whenever the capital-to-assets ratio of the bank $\frac{BK_t(i)}{L_t(i)}$ moves away from the exogenously set optimal value . The bank capital adjustment cost is specified as

$$\Phi_t^{BK} = \frac{\phi_{BK}}{2}\left[\frac{BK_t(i)}{L_t(i)} - CAR\right]^2 BK_t(i) \qquad (48)$$

where ϕ_{BK} denotes the bank capital adjustment cost parameter. The wholesale branch manages the capital position of the group, and we assume that bank capital is accumulated each period out of retained earnings

$$BK_t(i) = (1-\delta_{bk})BK_{t-1}(i) + \chi^{bk}\Pi_{t-1}^{bk}(i) - \varepsilon_t^{BK} \qquad (49)$$

where δ_{bk} denotes depreciation rate of bank capital due to bank capital management and overall banking intermediation activity and ε_t^{BK}

the negative shock to bank capital to model credit tightening.

The wholesale branch decides on the optimal level of loans $L_t(i)$ and deposits $D_t(i)$ to maximizes profits

$$\Pi_t^{wb} = i_t^{w_l} L_t(i) + i_t^T \alpha^T D_t(i) - i_t^{w_d} D_t(i) - BK_t(i) - \Phi_t^{BK} \quad (50)$$

subject to the balance sheet constraint in Eq. (44). Solving this profit maximization problem yields an optimality condition that links the spread between wholesale rates on loans $i_t^{w_l}$ and deposits $i_t^{w_d}$ to the degree of bank's leverage position $\frac{L_t(i)}{BK_t(i)}$:

$$i_t^{w_l} = \kappa i_t^{w_d} - \phi_{BK}\left[\frac{BK_t(i)}{L_t(i)} - CAR\right]\left[\frac{BK_t(i)}{L_t(i)}\right]^2 + \frac{\alpha^T}{RR_t + \alpha^T - 1} i_t^T \quad (51)$$

where $\kappa = \frac{1}{1 - RR_t - \alpha^T}$. In addition, we assume that banks can invest excess funds in the SDA facility of the central bank, from which they get remunerated at rate i_t^{SDA}. Assuming that there exists no arbitrage between the SDA facility and the deposit market in the interbank market, we have $i_t^{w_d} = i_t^{SDA}$. Hence, the optimality condition above becomes

$$i_t^{w_l} = \kappa i_t^{SDA} - \phi_{BK}\left[\frac{BK_t(i)}{L_t(i)} - CAR\right]\left[\frac{BK_t(i)}{L_t(i)}\right]^2 + \frac{\alpha^T}{RR_t + \alpha^T - 1} i_t^T. \quad (52)$$

Invoking the central bank's policy rate-SDA rate identity $i_t = i_t^{SDA}$ and imposing a symmetric equilibrium in the interbank market, this reduces to the condition

$$i_t^{w_l} = \hat{i}_t - \phi_{BK}\left(\frac{BK_t}{L_t} - CAR\right)\left(\frac{BK_t}{L_t}\right)^2 + \frac{\alpha^T}{RR_t + \alpha^T - 1} i_t^T \quad (53)$$

where $\hat{i}_t = \kappa i_t$. This optimality condition links the wholesale loan rate $i_t^{w_l}$ prevailing in the interbank market to the central bank's main policy rate i_t and T-bill rate i_t^T, on one hand, and to the leverage position $\frac{L_t(i)}{BK_t(i)}$ of the banking sector as well as to the reserve requirements and banks' holdings of government securities on the other.

Hence, the optimality condition above implies that the optimal decision of banks is to choose a level of loans (and thus of leverage position given bank capital) such that the marginal cost for reducing the capital-to-asset ratio after taking in account the exogenous variations in the T-bill rate and reserve requirements exactly equals the deposit-loan spread $spread_t^W$ given by

$$spread_t^W = i_t^{w_l} - \hat{i}_t = -\phi_{BK}\left(\frac{BK_t}{L_t} - CAR\right)\left(\frac{BK_t}{L_t}\right)^2 + \frac{\alpha^T}{RR_t + \alpha^T - 1} i_t^T. \quad (54)$$

Thus, the spread is, on the one hand, a negative function of the overall leverage of the banking sector,[5] and on the other, a positive function of the T-bill rate.[6]

Retail branch. The retail branch consists of the lending and savings banks. Both banks operate in a monopolistically competitive environment; they maximize profits by setting retail loan and deposit rates. We introduce nominal rigidities in interest rate setting of the retail branch in the form of sticky retail interest rates, that is, both lending and savings banks face quadratic adjustment costs $\Phi_t^{i^d}$, $\Phi_t^{i^{l_{im}}}$ and $\Phi_t^{i^{l_e}}$ in setting interest rates:

$$\Phi_t^{i^d} = \frac{\phi_{i_d}}{2}\left[\frac{i_t^d(i)}{i_{t-1}^d(i)} - 1\right]^2 D_t \quad (55)$$

$$\Phi_t^{i^{l_{im}}} = \frac{\phi_{i_{l_{im}}}}{2}\left[\frac{i_t^{l_{im}}(i)}{i_{t-1}^{l_{im}}(i)} - 1\right]^2 L_t^{im} \quad (56)$$

$$\Phi_t^{i^{l_e}} = \frac{\phi_{i_{l_e}}}{2}\left[\frac{i_t^{l_e}(i)}{i_{t-1}^{l_e}(i)} - 1\right]^2 L_t^e. \quad (57)$$

The lending banks obtain the wholesale loans $L_t(i)$ from the wholesale branch at the interest rate of $i_t^{w_l}$ and then differentiate them at no cost and delegate them to entrepreneurs who use them to finance capital acquisition and to borrowing households who use them to finance housing assets. The lending bank maximizes profits

$$\Pi_t^{rl} = i_t^{l_{im}}(i)L_t^{im}(i) + i_t^{l_e}(i)L_t^e(i) - i_t^{w_l}L_t(i) - \Phi_t^{i^{l_{im}}} - \Phi_t^{i^{l_e}} \quad (58)$$

subject to the demand functions in Eqs. (48) and (51). This yields the optimal retail loan rates for borrowing households and entrepreneurs (after imposing a symmetric equilibrium):

$$i_t^{l_{im}} = \frac{\vartheta_{l_{im},t}}{\vartheta_{l_{im},t}-1} i_t^{w_l} - \frac{\phi_{i_{l_{im}}}}{\vartheta_{l_{im},t}-1}\left(\frac{i_t^{l_{im}}}{i_{t-1}^{l_{im}}}-1\right)\frac{i_t^{l_{im}}}{i_{t-1}^{l_{im}}} + \beta_p \frac{\phi_{i_{l_{im}}}}{\vartheta_{l_{im},t}-1}\left(\frac{i_{t+1}^{l_{im}}}{i_t^{l_{im}}}-1\right)\frac{i_{t+1}^{l_{im}}}{i_t^{l_{im}}}\frac{L_{t+1}^{im}}{L_t^{im}} \quad (59)$$

$$i_t^{l_e} = \frac{\vartheta_{l_e,t}}{\vartheta_{l_e,t}-1} i_t^{w_l} - \frac{\phi_{i_{l_e}}}{\vartheta_{l_e,t}-1}\left(\frac{i_t^{l_e}}{i_{t-1}^{l_e}}-1\right)\frac{i_t^{l_e}}{i_{t-1}^{l_e}} + \beta_p \frac{\phi_{i_{l_e}}}{\vartheta_{l_e,t}-1}\left(\frac{i_{t+1}^{l_e}}{i_t^{l_e}}-1\right)\frac{i_{t+1}^{l_e}}{i_t^{l_e}}\frac{L_{t+1}^{e}}{L_t^{e}}. \quad (60)$$

The optimality conditions above link retail loan rates set by banks to the wholesale loan rate, which is the relevant marginal cost for retail lending banks and which depends on the policy rate, capital position of the bank, reserve requirements, and T-bill rate.

We assume that there are no adjustment costs in the steady state, hence in a fully flexible environment we have

$$i_t^{l_x} = \frac{\vartheta_{l_x,t}}{\vartheta_{l_x,t}-1} i_t^{w_l} \quad (61)$$

where $x = im, e$. Hence, interest rates on loans are a markup over the marginal cost (wholesale loan rate). Calculating for the spread between the retail loan and policy rates $spread_t^{rl}$, we have

$$spread_t^{rl} = i_t^{l_x} - \hat{i}_t = \frac{\vartheta_{l_x,t}}{\vartheta_{l_x,t}-1} spread_t^W + \frac{1}{\vartheta_{l_x,t}-1}\hat{i}_t. \quad (62)$$

Observe that the spread between retail loan and policy rates is a direct function of the spread between wholesale loan and policy rates, which reacts to variations in the overall leverage position of the bank, reserve requirements, as well as T-bill rates. In addition, observe the role of exogenous markup shocks in the interest rate setting of lending banks: a positive markup shock increases market power thus forces loan rates to diverge more from the policy rate, that is, $spread_t^{rl}$ widens.

The deposit banks behave in a reverse fashion. They collect deposits $D_t(i)$ from borrowing households and pass them to the wholesale branch which pays them the interest rate $i_t^{w_d}$. It maximizes profits by:

$$\Pi_t^{rd} = i_t^{w_d} D_t(i) - i_t^d(i) D_t(i) - \Phi_t^{i^d}(i) \quad (63)$$

subject to the demand function in Eq. (45). This yields the optimal retail deposit rate (after imposing a symmetric equilibrium)

$$\frac{1+\vartheta_{dep,t}}{\vartheta_{dep,t}} i_t^d = i_t^s - \frac{\phi_{i_d}}{\vartheta_{dep,t}}\left(\frac{i_t^d}{i_{t-1}^d}-1\right)\frac{i_t^d}{i_{t-1}^d} + \beta_p \frac{\phi_{i_d}}{\vartheta_{dep,t}}\left(\frac{i_{t+1}^d}{i_t^d}-1\right)\frac{i_{t+1}^d}{i_t^d}\frac{D_{t+1}}{D_t}. \quad (64)$$

In steady state, we have

$$i_t^d = \frac{\vartheta_{dep,t}}{\vartheta_{dep,t}-1} i_t^{w_d}. \quad (65)$$

Assuming no arbitrage in the central bank's SDA facility implies that $i_t^{w_d} = i_t^{SDA}$ and invoking the policy rate-SDA rate identity, the above equation reduces to

$$i_t^d = \frac{\vartheta_{dep,t}}{1+\vartheta_{dep,t}} i_t = \frac{|\vartheta_{dep,t}|}{|\vartheta_{dep,t}|+1} i_t. \quad (66)$$

With fully flexible rates, i_t^d is a static mark-down over the policy rate.

Overall profits of bank i (wholesale and retail branches combined) is given by

$$\Pi_t^b(i) = i_t^{l^{im}}(i) L_t^{im}(i) + i_t^{l^e}(i) L_t^e(i) - i_t^d(i) \tag{67}$$
$$D_t(i) - \Phi_t^{i^{l^{im}}} - \Phi_t^{i^{l^e}} - \Phi_t^{i^d} - \Phi_t^{BK}.$$

The Central Bank: Monetary Policy and Macroprudential Regulation

The central bank sets the policy rate i_t using the Taylor rule

$$\log i_t = \lambda_i \log i_{t-1} + (1-\lambda_i)\log i^{ss} + \tag{68}$$
$$\lambda_\pi \log\left(\frac{\pi_t}{\pi^{ss}}\right) + \lambda_Y \log\left(\frac{Y_t}{Y^{ss}}\right) + \log \varepsilon_t^i.$$

where λ_i, λ_π, and λ_Y are the weights assigned to interest rate smoothing, inflation gap, and output gap, respectively, i^{ss} the steady state policy rate, Y^{ss} the steady state output, and ε_t^i an i.i.d. shock to monetary policy.

The monetary policy suite of the central bank also includes the SDA rate and the reserve requirements. The central bank sets the reserve requirements according to

$$RR_t = (1-\rho_{RR}^{PS})(\rho_{RR}^{\pi}\pi_t + \rho_{RR}^{Y}Y_t) + \rho_{RR}^{PS} RR_{t-1} + \varepsilon_t^{RR} \tag{69}$$

where RR^{ss} is the steady state reserve requirement and ε_t^{RR} is an i.i.d. shock to reserve requirements.

The macroprudential policy instruments LTV_t and CAR are set according to

$$LTV_t = (1-\rho_{LTV})LTV^{ss} + \rho_{LTV} LTV_{t-1} + \varepsilon_t^{LTV} \tag{70}$$

where LTV^{ss} is the steady state loan-to-value ratio and ε_t^{LTV} an i.i.d. shock to LTV, while we calibrate the value of CAR to 0.08, a level consistent with much of the regulatory capital requirements for banks.

In our policy experiments, we look at different specifications of the macroprudential measures. Following Sinclair and Sun (2014), we assume that the LTV ratio requirement also responds to asset (housing) prices and loans,[7]

$$LTV_t = \rho_{LTV} LTV_{t-1} + (1-\rho_{LTV})(\rho_H P_{H,t+1} + \rho_L L_t) + \varepsilon_t^{LTV}. \tag{71}$$

We also look at the implications of introducing a countercyclical CAR requirement instead of fixing it at a constant value. We follow the specification of Angelini, Neri, and Panetta (2010):

$$CAR_t = (1-\rho_{CAR})CAR^{ss} + (1-\rho_{CAR})(g_t^Y - g_{ss}^Y) + \rho_{CAR} CAR_{t-1} \tag{72}$$

where we set the steady state level CAR^{ss} equal to the steady state of banks' capital-to-asset ratio $\frac{BK_t}{L_t}$ and g_t^Y denotes the growth of output while g_{ss}^Y the steady state output growth. In this case, the macroprudential measure CAR acts as a countercyclical policy: CAR increases during good times, that is, when g_t^Y exceeds steady state/potential output growth and, conversely, declines during bad times, that is, when output growth is below its steady state. Finally, we look at the potential of reserve requirements ratio as both monetary and macroprudential tool by using the following specification following Glocker and Towbin (2012):

$$RR_t = \rho_{RR}^{FS} RR_{t-1} + (1-\rho_{RR}^{FS})\rho_{RR}^{L} L_t + (1-\rho_{RR}^{PS})(\rho_{RR}^{\pi}\pi_t + \rho_{RR}^{Y}Y_t) + \varepsilon_t^{RR}. \tag{73}$$

CALIBRATION

Our calibration strategy is two-pronged. First, we use Philippine historical data for some of the parameters that can be calculated in a straightforward fashion (e.g. share of domestic goods in total consumption, share of exports in final goods production, etc.). Second, we use estimated/calibrated values of existing studies for the Philippines (e.g. Majuca, 2014; Aldaba, 2009; and McNelis, Glindro, Co, & Dakila, 2010) and for emerging markets (Harmanta, Purwanto, Rachmanto, & Oktiyanto, 2013). We also use the estimated values of Gerali et al. (2010) for some of the parameters related to the banking sector. Table 1 summarizes our calibration strategy.

Table 1: *Calibrated Parameters*

Parameter	Notation	Value
Home bias	γ	0.8
Inverse of Frisch elasticity	σ_n	1.73
Saving households' discount factor	β_p	0.99
Borrowing households' discount factor	β_{im}	0.975
Depreciation rate of capital	δ_k	0.025
Depreciation rate of housing assets	δ_h	0.0125
Share of capital in production	ψ	0.33
Interest rate smoothing	λ_i	0.9
Weight of inflation in Taylor Rule	λ_π	1.5
Weight of output gap in Taylor rule	λ_Y	0.13

POLICY SIMULATIONS AND DISCUSSION

In this section, we investigate the responses of variables to an unanticipated shock to monetary policy. To examine the implications of macroprudential regulation to the real economy, we look at the responses in the benchmark model to a negative shock to LTV ratio requirement, negative shocks to total factor productivity (TFP) and bank capital under models with CAR and no CAR requirements and high (20.0 percent) and normal (10.0 percent) CAR requirements, and a negative shock to bank capital under models with high and low bank capital adjustment costs. Finally, we assess the importance of adjusting the reserve requirements as part of the central bank's monetary policy suite as well as its potential as a tool of financial stability. Towards this end, we compare the transmission mechanism of both the main policy rate and the reserve requirements ratio.

Banking Intermediation, Financial Frictions, and the Transmission of Monetary Policy

We look at the impulse responses of variables to an unanticipated 100 basis points increase in the central bank's policy rate to analyze the transmission mechanism of monetary policy. To understand the role of financial frictions, we compare the impulse responses of the benchmark model with the impulse responses of the no financial frictions (No-FF) model. We examine the role of banking intermediation in the transmission mechanism of monetary policy by comparing the responses of the benchmark model with those of the no bank capital (No-BK), no bank capital with no bank market power (No-BK-MP), and perfectly competitive bank (PCB) models.

Figure 1 compares the responses in the benchmark model against those in the PCB model. It highlights the role of banking intermediation

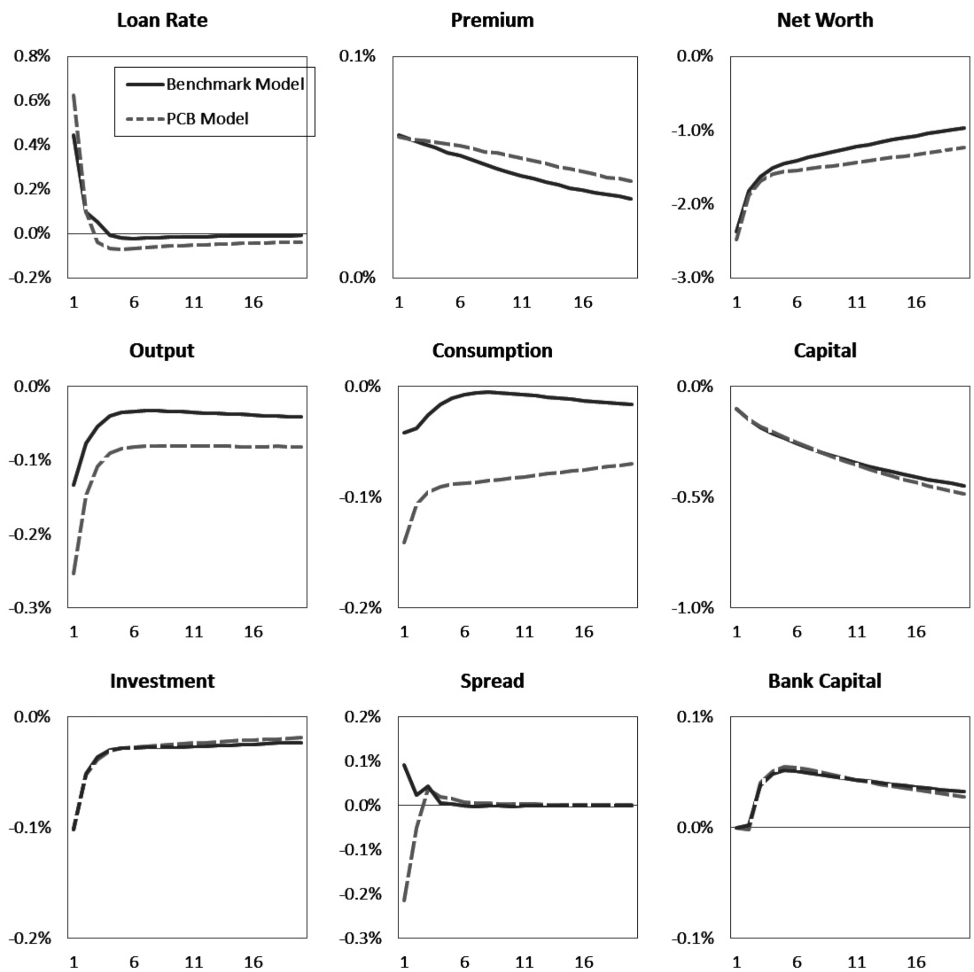

Figure 1: Responses to a monetary policy shock: Benchmark vs PCB Model

in the transmission of monetary policy: the monopolistically competitive banking sector has an impact attenuator effect as the responses of variables to monetary tightening suggest. Under the PCB model, the bank lending channel compels borrowers to incur a higher cost of borrowing as reflected by the higher loan rate. This translates to higher contraction in output, consumption, capital, net worth, and investment. In contrast, the presence of a monopolistically competitive banking sector attenuates the impact of the contractionary monetary policy. In particular, the monopolistically competitive banking sector mutes the increase in the loan rate by 1.4 times, hence the increase in the external finance premium is dampened by about 1.2 times and the net worth of entrepreneurs worsens by about 1.3 times less than in the PCB model. The net effect is a dampening of the contraction in output and consumption by almost two times and 4.2 times of the contraction under the PCB model.[8]

Implications of Macroprudential Regulation for the Real Economy

Macroprudential tools are primarily designed to address the procyclicality in the financial system in order to achieve financial stability.[9] Macroprudential tools designed to address financial system procyclicality include countercyclical capital requirements, minimum CAR requirements, maximum LTV ratio requirements, loan loss provisions, and haircuts and margining practices in securities financing and over-the-counter (OTC) derivatives transactions, among others.

Our analysis shows the implications of macroprudential tools LTV ratio requirement and CAR requirement for the real sector of the economy. This allows us to assess the effectiveness of such macroprudential tools in providing stability in the financial system. In particular, we look at the responses in the benchmark model to a negative shock to LTV ratio requirement, negative shocks to TFP and bank capital under models with CAR and no CAR requirements and high (20.0 percent) and normal (10.0 percent) CAR requirements, and a negative shock to bank capital under models with high and low bank capital adjustment costs.

Loan-to-value ratio. As a means of reducing the exposure of banks to particular sectors in the economy such as real estate and housing as well as to regulate concentration risk, central banks set the maximum LTV ratio requirement on loans as well as the maximum loan exposure to such sectors.[10]

As Figure 2 suggests, reducing the LTV ratio requirement successfully achieves the central bank's goal of dampening the exposure of banks to housing and real estate sectors as well as reducing concentration risk. In particular, tightening the LTV ratio requirement cuts sharply the value of housing assets which, in turn, leaves impatient households with fewer resources to finance their borrowing from banks. As a result, loans contract sharply.[11] However, although this form of macroprudential regulation is effective in terms of safeguarding stability among financial institutions, it comes with costly implications for the real sector. As explained above, the LTV ratio

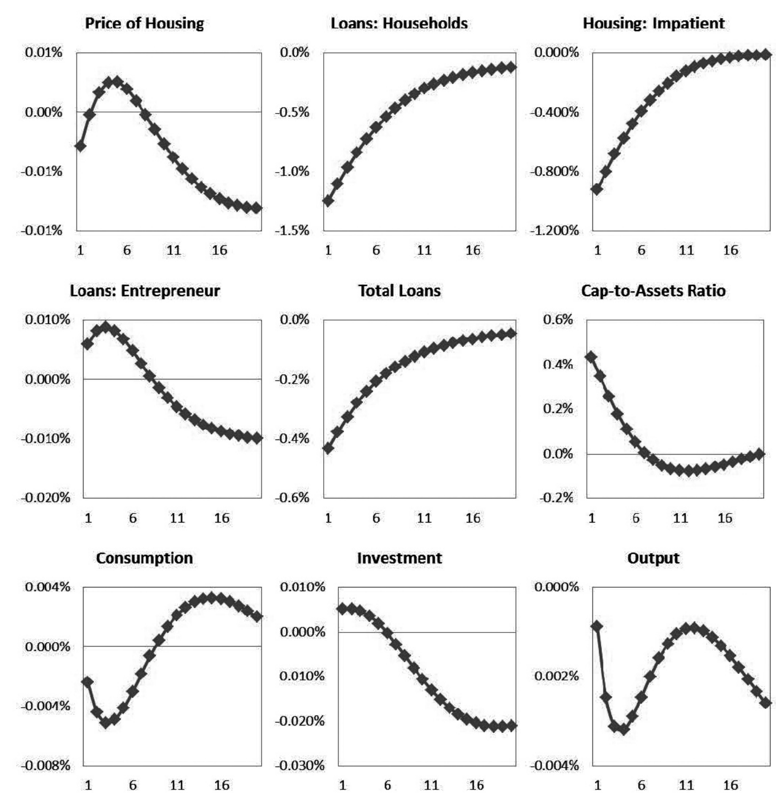

Figure 2: Responses to a negative shock to loan-to-value ratio

determines the collateralizeable proportion of the assets' value held by borrowers. Hence, when the central bank tightens the LTV ratio requirement, the amount of loans borrowers can purchase also decreases. Although banks compensate for this by raising more loans for entrepreneurs, the net effect is a decline in overall credit. This weakens domestic demand due to fewer resources to finance consumption of final goods and housing assets. The end result is a sizeable contraction in consumption, investment (after five quarters), and ultimately output.

Thus, our results show that macroprudential tools such as the LTV policy, while in essence designed to address financial stability, must be set in coordination with monetary policy, and set with due regard to their possible effects to the short-run business cycle fluctuations in the macroeconomy.

Capital adequacy ratio. Figures 3 and 4 show the responses to a one percent TFP shock in models with CAR and no CAR requirements, and models with high CAR requirement (20%) and low CAR requirement (10%), respectively. In both of these models, the negative TFP shock pulls down the return to capital, hence the contraction in both investment and output. The shock increases firms' marginal cost of production, hence inflation rises. The slump in the price of capital worsens the net worth of entrepreneurs. The increase in inflation results to real appreciation. The central bank responds to higher inflation by raising the policy rate, which in turn makes domestic borrowing more costly due to higher lending rate. As a result, demand for credit contracts, which further pulls down output.

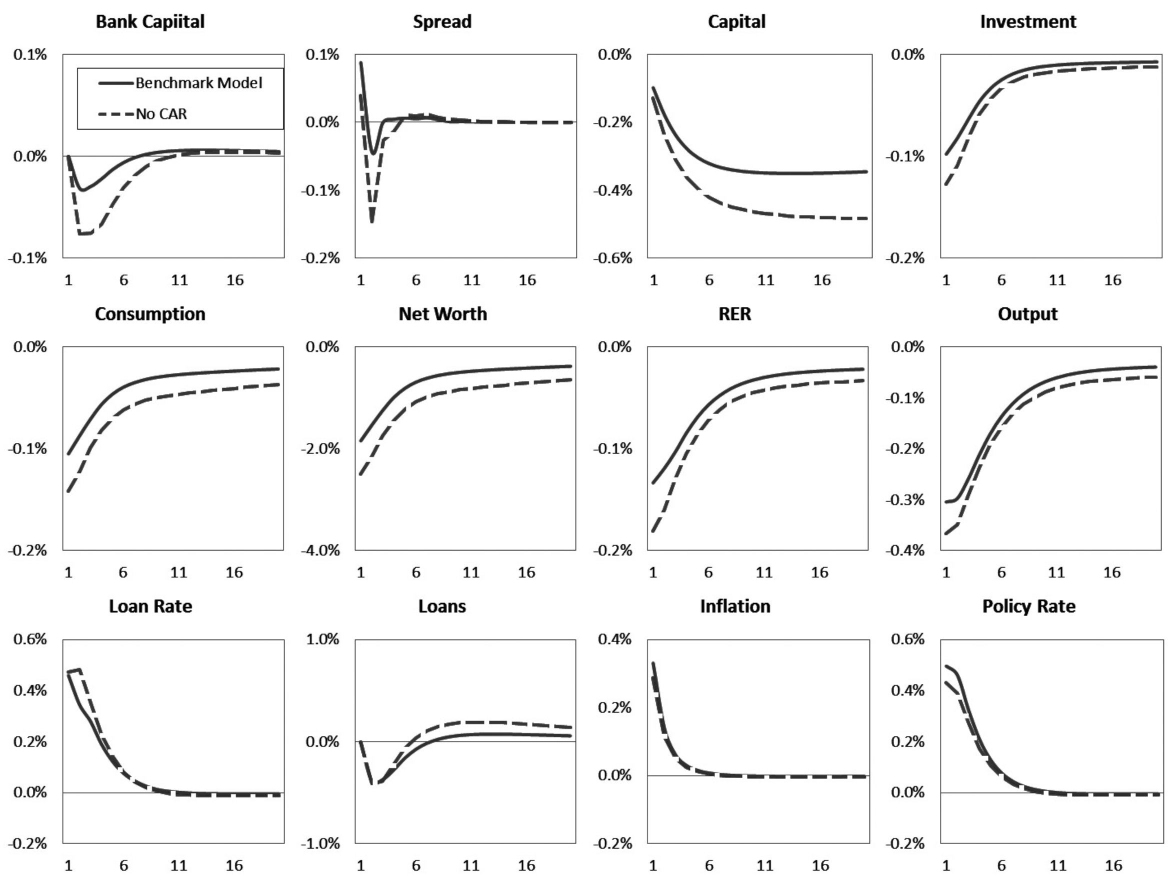

Figure 3: Responses to a negative shock to total factor productivity: Benchmark vs No CAR model

The central bank sets the CAR requirement imposed among banks as a way of regulating capitalization of bank and ensure stability and prudent intermediation activity among banks. Figure 3 shows that the CAR requirement achieves the goal of reducing procyclicality and ensuring the resilience of the financial system and the economy as a whole. In particular, capital regulation dampens the contraction in bank capital as a result of a negative TFP shock by 2.4 times. As a result, the volatilities in the real economy are muted. Capital declines by 1.4 times less under the presence of capital regulation. Likewise, the drop in investment, consumption, net worth, and real exchange rate are all muted. The end result is a reduction in output volatility by 1.2 times under regulatory capital requirements.

Overall, in contrast to previous studies,[12] our study brings to the fore the costs of regulatory capital requirements on the real side of the economy. Our results, for example, reveal that although minimum CAR requirements achieve the goal of ensuring stability in the financial system, the minimum CAR requirement may have some effects to the short-run business cycle fluctuations in the real side of the economy. In particular, under our simulations, capital regulation induces more inflationary pressures, forcing the central bank to raise the policy rate at a higher level compared when regulatory capital requirements are not enforced. Under the benchmark model, inflation picks up by 1.2 times higher under capital regulation policies.

To further highlight the costs associated with regulatory capital requirements, we examine

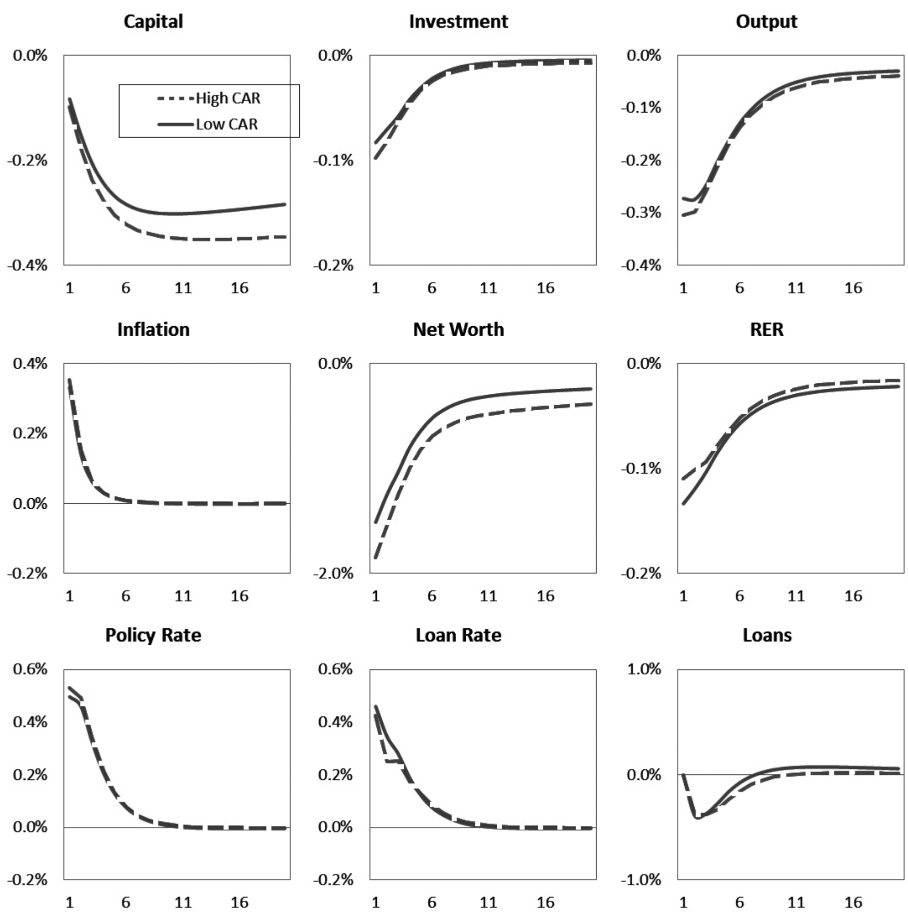

Figure 4: Responses to a negative shock to total factor productivity: High vs low CAR

the responses when the central bank decides to raise the CAR requirement to 20%. As Figure 4 shows, the level of CAR requirement set by the central bank has substantive implications for the real sector especially when a negative shock hits the economy. In particular, a higher CAR requirement magnifies the impact of the negative shock. Capital declines by 1.2 times more under the CAR requirement; the same applies to investment and net worth. The end result is a contraction in output that is larger by 1.1 times compared when CAR requirement is not imposed among banks.

4.2.3 Reserve requirements ratio. Figure 5 presents the responses to a 50 basis points increase in the reserve requirements ratio. Raising the reserve requirements ratio achieves the price stability goal by reducing inflation. At the same time, increasing the reserve requirements ratio reduces the resources available for banks, thus affecting their ability to create loans. To compensate for this, banks raise the loan rates, which increases the cost of borrowing for both impatient households and entrepreneurs. Entrepreneurs' net worth decline, and this pushes the external finance premium upwards, which in turn pulls down demand for capital, investment, and output. Through the financial accelerator mechanism, higher external finance premium causes both investment and output to contract further. Fewer resources left for banks force them to raise more deposits. Consumption goes down with the declining domestic demand and this results to an apparent slowdown in economic activity.

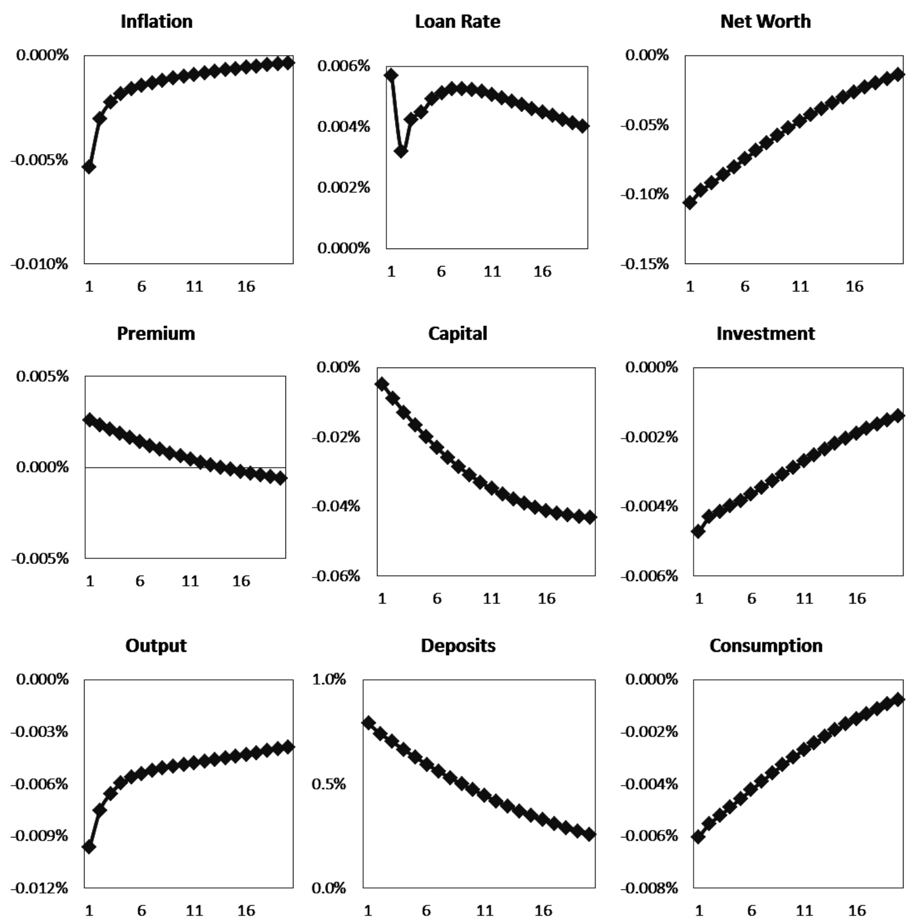

Figure 5. Responses to a positive shock to reserve requirements ratio

Main policy rate and reserve requirements ratio. Figure 6 shows that both the policy rate and the reserve requirements ratio achieve the goal of stabilizing the price level in the economy, as reflected by the drop in inflation. The results suggests that varying the main policy instrument is more effective as a tool for price stability than adjusting the reserve requirements ratio. This notwithstanding, changes in the reserve requirements ratio cause less reduction in net worth, capital, investment, consumption, and output. This advantage of the reserve requirements ratio comes from the interest rate channel. The increase in the policy rates forces banks to raise loan rates contemporaneously by almost 0.5 percentage points, significantly higher than 0.06 percentage points increase in response to changes in reserve requirements ratio. The higher loan rates increases the cost of borrowing for both impatient households and entrepreneurs, and the financial accelerator mechanism leads to further contraction in the real economy.

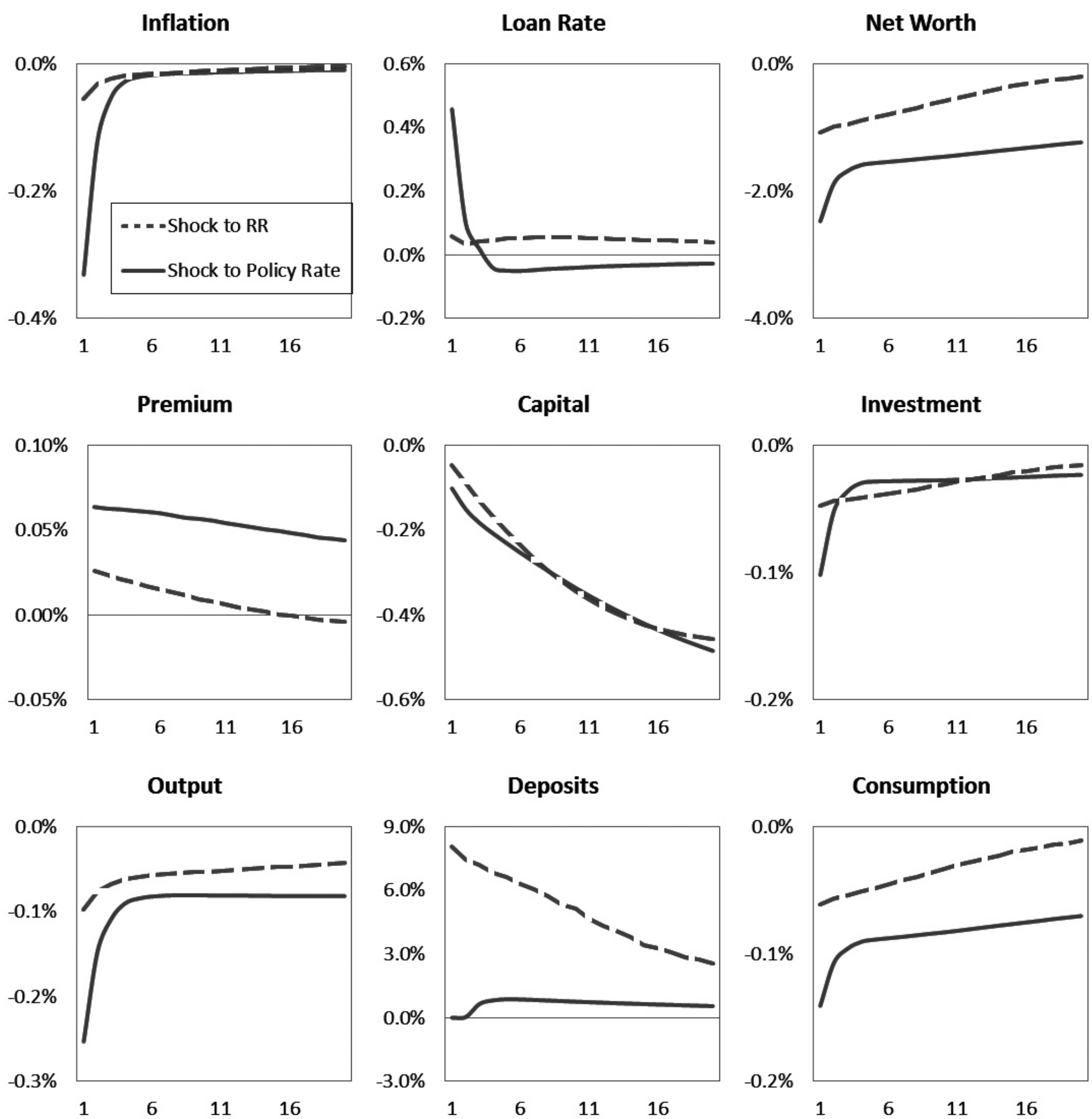

Figure 6. Responses to shocks to the main policy rate and reserve requirements ratio

CONCLUSIONS

In this paper, we developed a small, open-economy DSGE model of the Philippines that features financial-real linkages, banking intermediation, and macroprudential regulation. We used this model to understand the role of banking intermediation and financial frictions in the transmission of monetary policy, as well as to examine the implications to the real economy of macroprudential measures used by the central bank to safeguard financial stability among banks.

The results of our research suggests the following: First, although the macroprudential tools used by the central bank may achieve the goal of safeguarding financial stability of the banking system, it is important to be aware of their effects to the short-run business cycle fluctuations of the macroeconomy. In particular, while capital regulation improves capitalization and hence balance sheet of banks, it may induce more inflationary pressures. And while stricter LTV ratio requirement results in reduced exposure of banks to the real estate sector as well as regulated concentration risks, it may result in the dampening of domestic demand. These suggest that it may be ideal for macroprudential tools to be set in coordination with monetary policy, in order to reduce the possibility that an uncoordinated policy setting may affect the short-run fluctuations of the real economy.

This insight poses important implications for the monetary authorities moving towards an institutionalized framework for macroprudential policy.[13] The results of our research suggest the need to take into consideration the possible consequences to the real sector of the economy of such macroprudential tools.

The results also suggest that the presence of banking and financial frictions amplifies the magnitude and persistence of shocks hitting the economy, particularly the propagation mechanism of monetary policy. However, monopolistic competition in the banking sector attenuates the impact of monetary tightening as suggested by the responses of variables to the monetary policy shock. Finally, the use of reserve requirements as both a tool geared towards price and financial stability can have substantial contribution in achieving macroeconomic stabilization. Our simulations seem to suggest that the use of the policy rate may be a more effective as a tool for price stability than adjustment of the reserve requirements ratio.

NOTES

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2 For instance, the BSP set the maximum loan exposure to real estate at 20.0% and reduced loanable value of real estate used as collateral for bank loans to a maximum of 60.0%, in order to combat the negative spillovers of the foreign exchange crisis in 1997 (BSP Circular Letters, 1997).

3 In particular, when a negative shock hits the economy and the value of the entrepreneur's assets decreases as a result of the shock, the borrowing capacity as well as credit worthiness of the entrepreneur worsens. As a result, there is less demand for capital and this in turn exacerbates the negative impact of the shock by reducing the entrepreneur's investment. The end result is a larger contraction in the economy.

4 For simplicity, we assume that this takes place within the same period and hence rental rate is zero.

5 When banks are scarcely capitalized and regulatory capital requirements become more binding (i.e. when leverage increases), the spread decreases and hence margins become tighter.

6 The divergence of market rates from policy rates expands as a result of exogenous positive variations in the T-bill rate.

[7] Sinclair and Sun (2014) cited three main justifications of this LTV rule: (i) housing prices contain relevant information about aggregate price movements; (ii) the response of monetary policy to asset prices is an important tool for macroeconomic stabilization (see Bernanke and Gertler (1999) and Cecchetti, Genberg, Lipsky, and Wadhwani (2000), among others]; and (iii) the asset price volatility is a key indicator for financial stability [see Bernanke and Gertler (1999) and Borio and Lowe (2002), among others].

[8] This impact attenuator effect operates through two ways. On the one hand, monopolistic competition gives banks some degree of market power, which in turn leads to a steady state disparity or "wedge" between retail bank rates and the policy rate. The markup that banks set on the loan rate causes the weak percent variation of the loan rate with respect to variations in the policy rate. On the other hand, sticky interest rate-setting of banks in the form of adjustment costs allows for the imperfect pass-through of policy rate to bank rates. The sticky bank rates prevents banks to fully pass on the increase in the policy rate to retail rates. Both of these features—which are absent in the PCB model—result to the attenuation of the monetary tightening. Lending rate increases less in the benchmark model than in the PCB model, hence the impact of the contractionary monetary shock on output, consumption, capital, net worth, and investment is dampened under the benchmark model. This attenuation effect is in line with much of the findings in the literature, particularly those of Gerali et al. (2010), Goodfriend and McCallum (2007), Andres and Arce (2008), and Aslam and Santoro (2008).

[9] One important distinction in the literature is between macroprudential tools geared towards addressing the time-series dimension of financial stability—the procyclicality in the financial system—and tools that are geared towards addressing the cross-sectional dimension of financial stability—how risk is distributed at a point in time within the financial system/contributions to systemic risk of individual institutions (Galati & Moessner, 2011).

[10] For example, in June 1997, the BSP set the maximum loan exposure to real estate at 20% and reduced the LTV ratio of real estate used as collateral for bank loans to 60%, both of which were vital in combating the negative spillovers of the foreign exchange crisis in 1997 (BSP Circular Letters, 1997).

[11] As expected, amount of housing assets demanded by impatient households falls due to the lack of resources to finance them. The decline in household credit encourages banks to manage their asset portfolio by increasing the volume of credit extended to entrepreneurs. The net effect on total loans is negative, reflecting that the contraction in household credit outweighs the expansion in loans for entrepreneurs. As a result, banks' capital-to-asset ratio rises. This reflects that reducing the LTV ratio requirement achieves central bank's goal of regulating banks' exposure to housing and real estate sectors and the associated concentration risks.

[12] See Galati and Moessner (2011) for a comprehensive survey of literature.

[13] In the Philippines, the central bank launched in September 2010 a high-level Financial Stability Committee (FSC) chaired by the BSP Governor with its deputy directors and senior officials as members. The FSC is tasked to define the "appropriate vision and work plan to adequately mitigate the buildup of systemic risk under a Financial Stability objective" (Tetangco, 2013, p.3 cite material here page of quoted line and provide corresponding reference entry). The establishment of the FSC has allowed for a higher level of authority in providing a framework for financial stability. To foster a strong financial and resilient financial system that supports market innovation and mitigates any build-up of systemic risks, the BSP has formalized the creation of the Financial Stability Coordination Council (FSCC) on January 2014. The FSCC is a voluntary interagency council composed of the BSP, Department of Finance (DOF), IC, PDIC, and SEC. The key objective of the interagency council is to identify, manage, and mitigate the buildup of systemic risks, all consistent with the overall prudential objective of financial stability.

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