A CREDIT AND BANKING MODEL FOR EMERGING MARKETS AND AN APPLICATION TO THE PHILIPPINES

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Abstract

The paper develops a small open economy New Keynesian DSGE model with financial frictions and an active banking sector for emerging markets, in order to understand the role of banking intermediation in the transmission of monetary impulses, and to analyze how shocks that originate in credit markets are transmitted to the real economy. The DSGE model builds-in many of the features of emerging markets such as rigidities in interest rate pass-through, “financial accelerator” effects and foreign currency borrowing by firms, a credit supply channel, as well as impact of conventional and unconventional monetary policies. The analysis delivers the following results. First, the presence of financial frictions amplifies the magnitude and the persistence of transitory shocks. Second, market power of monopolistic banking sector amplifies the business cycle. However when interest rates are sticky, banking system attenuate the response to shocks. Third, the tightening of credit markets (modeled by a persistent negative shock to bank capital) can have substantive effects on the economy. Fourth, when the central bank resorts to using non-monetary tools, there is a larger contraction in output and consumption as compared to traditional monetary tightening (operating through nominal interest rate changes). These results are driven by the two channels through which the financial sector interacts with the real economy – the financial accelerator channel, which establishes a link between the balance sheet of the firms (borrowers) and the real economy; and the banking channel, which creates a feedback loop between the real and the financial side of the economy through the bank’s balance sheet.

A. Introduction

The global financial crisis has amply demonstrated that the performance of the real side of the economy is closely linked to the disturbances in the financial sector. Shocks originating in the credit markets have resulted in substantial loss of output and large-scale unemployment. Inter-bank markets froze; credit became extremely costly, and at times

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totally unavailable. Tighter credit conditions not only exacerbated, but also protracted the crisis. Realizing that the recovery of the real economy depends crucially on the smooth functioning of the financial sector, central banks have taken substantive measures to unclog the credit markets. To analyze and understand these linkages better, it is imperative to develop a dynamic stochastic general equilibrium (DSGE) model with macro-financial linkages and an active banking sector.

The importance of financial shocks in terms of how they affect the real economy has long been realized (Fisher, 1933), but most of the general equilibrium models developed to study macro-financial linkages have focused only on the demand side of the credit markets. 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 growing importance of banks in the modern financial system and the current 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.

The objective of this paper is to develop a small open economy New Keynesian model with financial frictions and an active banking sector for emerging markets, in order to understand the role of banking intermediation in the transmission of monetary impulses, and to analyze how shocks that originate in credit markets are transmitted to the real economy. The model developed is used to analyze issues related to monetary transmission and financial stability. We specifically look at (1) the monetary transmission mechanism in the presence of banking sector and financial frictions; (2) the role of banks in propagation of macroeconomic shocks; (3) the effects of a tightening of credit conditions; and (4) the effects of non-standard monetary policy tools.

The credit and banking DSGE model builds-in many of the features of emerging markets that tend to be bank dominated and prone to surges in capital flows. To be concrete, we consider the example of the Philippines to inform the specification of the model but the characteristics of the model are quite general to emerging markets particularly emerging Asia. First, we allow rigidities in the pass through of policy or money markets interest rates to retail (deposit and lending) rates as observed in the Philippines. Second, surges in portfolio flows and liquidity can affect the networth or leverage of firms that determine the “external” finance premium and demand side “financial accelerator” effects. Moreover, considering that corporates in emerging market economies tend to also rely on foreign currency external borrowing in additional to domestic bank borrowing, exchange rate and world interest rate fluctuations through their effect on balance sheets can play an important role (Krugman, 1999, Aghion et al., 2001). Third, bank capital and financial stability concerns could impact the supply of credit as experienced during the global crisis. Another major contribution of this paper is to incorporate features to study the transmission mechanism of non-conventional

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2 Bernanke, Gertler and Gilchrist (1999) and Iacoviello (2005) have introduced credit and collateral requirements to analyze the transmission and amplification of financial shocks.
monetary policy tools. Unlike most models available in the literature, we consider the use of reserve requirements on bank deposits that are frequently used in many emerging Asian economies including the Philippines. Finally, we assess the use of liquidity requirements on banks or equivalently shocks to the share government debt securities held by banks that could be related to other factors such as portfolio shifts of non-resident investors in local currency government securities markets that have gained in importance.

We extend the small open economy DSGE model of Anand, Saxegaard and Peiris (2010) to include an active banking sector along the lines of Gerali and others (2010). Anand and others (2010) have shown that a model with financial frictions, modeled with a financial accelerator mechanism similar to Bernanke, Gertler and Gilchrist (1999), improves the model’s ability to capture the macro dynamics observed in India. The banking sector is modified to include the non-monetary tools frequently used by central banks in emerging Asia. We depart from Iocaviello (2005) and Gerali et al. (2010) in modeling financial frictions, that we only introduce the balance sheet effects for firms. Though such frictions may be an important feature of households’ balance sheets in advanced economies and some emerging markets, they have played a relatively secondary role in the Philippines for now and are excluded for parsimony.

We introduce a banking sector which operates under a monopolistically competitive environment. Banks are modeled as comprising of three parts, two “retail branches” and one “wholesale” unit. The two retail branches provide differentiated loans to entrepreneurs (loan branch) and raise differentiated deposits from households (deposit branch). These branches set rates in a monopolistic competitive fashion, subject to adjustment costs. The wholesale unit manages the capital position of the group and, in addition, raises wholesale loans and wholesale deposits. Banks combine deposits from the household and borrowing at interbank market with the bank capital to produce loans. While using deposits to make loans, banks observe cash reserve ratio (keeping a fraction of deposits in liquid form, which do not earn any interest) and statutory liquidity ratio (investing a fraction of deposits in government t-bills) imposed by the central bank or fixed exogenously. Cash reserve ratio requirements and statutory liquidity ratio requirements leave banks with fewer resources to lend. Both these factors increase the marginal cost of producing loans and affect the real side of the economy, through the borrowing costs of the firms. Bank capital is accumulated in each period out of retained earnings, and banks pay a quadratic cost if they deviate from the capital/loan requirement set by the central bank. Accumulation of bank capital from retained earnings creates a feedback loop between the real and the banking sector in the economy. As macroeconomic conditions deteriorate, profits of banks are affected negatively, and this weakens the ability of banks to raise new capital. Depending on the nature of the shock, this may force banks to cut down lending, or demand a higher price for credit, giving rise to the “credit cycle” observed in the recent recession episodes.

The paper is organized in five sections. In the next section, we present some empirical facts to further motivate the analysis, and also review the relevant literature. In Section C, we develop a small open economy New Keynesian model with financial frictions and an active banking sector, which forms the basis of further analysis. In Section D we analyze the impulse responses. Section E concludes.
B. Stylized Facts and Related Literature

We begin by presenting some basic stylized facts about the growing importance of macro-financial linkages and the banking sector in the Philippine economy and then look at the monetary policy practices in the Philippines. We also review the recent attempts at introducing banking sector in traditional DSGE models.

Household debt in the Philippines is relatively low compared to corporate debt and corporates still predominantly rely on bank borrowing to finance investment, although capital markets are starting to play a greater role. While Philippine companies finance the majority of their investment using retained earnings and bank finance, the share of external financing to GDP is more than double bank credit reflecting the importance of capital market financing and foreign debt financing. As a result, the Philippines’s corporate sector is exposed to global financing conditions, though the share of foreign currency denominated debt has fallen.

Capital inflows to the Philippines have surged since the beginning of 2010. There have been two other major episodes of capital inflows to the Philippines and emerging Asia more generally over the past two decades. The first episode began in the early 1990s and ended abruptly with the 1997-98 Asian financial crisis; the second began in the early 2000s and again ended abruptly with the global financial crisis. What is striking about the current episode is that surge in capital inflows to the Philippines has been predominately portfolio inflows to peso-denominated securities and other inflows to the non-financial private sector. This pattern in similar to the rest of emerging Asia, where portfolio flows have driven equity prices higher and local currency government bond yields lower. In addition, the increase in other liabilities has raised corporate leverage in a number of countries though less than Asian crisis levels (AREO 2014).

In the Philippines, the empirical relationship between non-FDI capital inflows and domestic demand is strong. The main channel through which the relationship seems to work is by reducing the cost of equity finance and expanding bank credit to the non-financial private sector. The impulse responses of Bayesian VARs show that non-FDI flows expands both private consumption and fixed investment, with a greater response of investment as expected. Easier external finance conditions enhance the borrowing capacity of corporates and expand the volume of bank and foreign debt financing resources available to them. Capital flows also tend to lower market interest rates and lead an expansion of credit possibly reflecting a search for yield and weakening of lending standards.

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3 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 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.

4 Government bond yields and real estate prices could also be an important transmission channel of capital flows and driver of domestic demand in EM Asia and the Philippines, although the historical analysis using BVARs did not show a significant impact. As financial markets further develop and housing finance
The Philippines shifted to an inflation targeting regime in 2002 (see Guinigundo, 2010). To achieve the inflation target, the BSP uses a suite of monetary policy instruments in implementing the desired monetary policy stance. The reverse repurchase (RRP) or borrowing rate is the primary monetary policy instrument of the BSP. Other monetary policy instruments include (a) increasing/decreasing the reserve requirement; (b) encouraging/discouraging deposits in the special deposit account (SDA) facility by banks and trust entities of BSP-supervised financial institutions; (c) adjusting the rediscount rate on loans extended to banking institutions on a short-term basis against eligible collateral of banks' borrowers; and (d) outright sales/purchases of the BSP's holding of government securities. Policy rates are supposed to anchor money market rates and Treasury bill/bond (T-bill) yields that act as benchmarks for deposit and loan rates. However, a recursive VAR shows that the transmission of the RRP to lending rates is imperfect and that the secondary market 91-day t-bill rates, foreign portfolio inflows, U.S. interest rates and the SDA rate could have a larger impact and explanatory power. In such an environment, allowing for interest rate rigidities and divergence of markets rates from policy rates would be important to take into account.\footnote{Peiris (2012) also shows a similar imperfect pass-through of policy rates to deposit rates in the Philippines.} The weak interest rate and credit channel may also explain the use of...
non-traditional monetary policy tools such as reserve requirements to carry out monetary policy operations. The BSP also merged its liquidity requirements that prescribed a level of liquid assets predominately government securities with the reserve requirement in 2012 but the share of bank assets held in debt securities remain significant. Thus, shocks to the share government debt securities held by banks as a result of policy or sudden changes of foreign participation in the bond market could be an additional source of fluctuations.

Figure 1.2 Dynamics of Market and Retail Interest Rates

Impulse Response of Retail Lending Rates

Variance Decomposition of Lending Rates

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6 The BSP unified the existing statutory reserve requirement and liquidity reserve requirement into a single set of reserve requirement as well as discontinued the renumeration of the unified reserve requirements in 2012.
Despite their relevance for policy making, most of the general equilibrium models generally lack interaction between financial markets and the real economy. Though a long tradition in economics starting from Irving Fishers’ (1933) debt deflation explanation of the Great Depression; most of the theoretical works focused on partial equilibrium analysis till the seminal paper by Bernanke and Gertler (1989). They used information asymmetry in credit markets and monitoring costs to establish a link between the financial sector and the real economy. They showed that in such a setting, the borrowing costs of firms depend on the strength of their balance sheets (net worth). Bernanke, Gertler and Gilchrist (1999), Kiyotaki and Moore (1997) and Carlstrom and Furest (1997) have demonstrated that the presence of financial frictions amplify the magnitude and the persistence of macroeconomic shocks. Gertler, Gilchrist and Natalucci (2007) and Eleckdag, Justiniano and Tchakarov (2005) extended the framework to small open economies. Iocaviello (2005) introduced the collateral constraints tied to real estate values of the firms and household level nominal debt to study the linkages between financial frictions and real economy. However all these models have used financial frictions on the firm/household side (or demand side of the credit market). All these models assume that credit transactions take place through markets, and do not assign any role to financial intermediaries such as banks. Also, they do not include the credit supply channel.

Recently there has been increasing interest in introducing a banking sector in dynamic models. The present crisis has underscored the need to model the supply side of credit markets to understand better the linkages between the financial sector and the real economy. In order to introduce the supply side of credit markets, researchers have followed three major approaches to model banking sector - (i) Perfectly competitive banks with banking costs; (ii) Monopolistically competitive banks and; (iii) Risky banks with inter-bank lending. All these models try to generate a spread between the lending and deposit rates which adjusts along the cycle, establishing a link between the banking activity and the real economy.

In models with perfectly competitive banks, banking (producing loans, deposits, bank equity etc.) is a costly activity which requires resources. Costs of banking activities create a spread between lending and deposit rates (Edward and Vegh, 1997; Benes et al., 2009; Curdia and Woodford, 2009; Goodfriend and McCallum, 2007; and Christiano et al., 2009). Models with monopolistically competitive banks use the market power of banks to generate a spread between the deposit and lending rates, which adjusts along the cycle, thus affecting the real side of the economy (Gerali et al., 2010; Huelsewig and Wollmershauser, 2009; and Sudo and Ternishi, 2009). Risky banks and inter-bank lending models assume that banks operate under perfectly competitive markets and the production of loans is separate from the production of deposits. Banks rely on inter-bank lending and there is an endogenous probability of default by firms and banks. This probability of default induces a financial accelerator in these models as the rate of default is countercyclical (de Walque et al., 2009; and Gertler and Kiyotaki, 2009).

7 It is commonly referred to in the literature as a “Financial Accelerator”. 
In this paper we follow Gerali et al. (2010) to introduce the banking sector in a model with financial frictions. Banks in our model operate in a monopolistically competitive environment and set deposit and lending rates. A wedge is created between the two rates as a result of the market power of banks. We model financial frictions a la Bernanke, Gertler and Gilchrist (1999).

C. The Model

We build on the model of Anand, Saxegaard and Peiris (2010) and include a banking sector on the lines of Gerali and others (2010). The basic structure of model consists of four kinds of agents – households, entrepreneurs, capital producers and retailers. Households consume a composite of domestic and imported goods and provide labor. They have access to foreign capital markets and make deposits with the banks. Households are the owner of banks and retail units. Entrepreneurs produce intermediate goods using labor and capital purchased from the capital producers. They finance the acquisition of capital partly through their net worth and partly through borrowing domestically (from banks) and from abroad. Banks raise deposits from households and give out loans to entrepreneurs. They operate in a monopolistically competitive environment – setting interest rates on deposits and loans to maximize profits. Banks combine deposits from the household and borrowing at inter-bank market with the reinvested profits (bank capital) to make loans to entrepreneurs. Entrepreneurs operate under perfect competition and sell their product to retailers who differentiate them at no cost and sell them either in domestic market or export overseas. Retailers operate in a monopolistically competitive environment and face a quadratic adjustment costs in changing prices à la Rotemberg (1982). Capital producers use a combination of existing capital stock and investment good purchased from retailers and abroad to produce capital. The market for capital, labor and domestic loans are competitive. The model is completed with a description of the fiscal and monetary authority.

In order to provide a rationale for monetary stabilization policy, three sources of inefficiencies are included in the model: (a) monopolistically competitive retail market; (b) sluggish price adjustment in retail sector and (c) capital adjustment costs. In addition sluggish interest rate adjustments and bank capital adjustment costs are the other sources of inefficiencies in the model. While relatively simple, the framework captures many of the rigidities which previous studies have found are important to describe the dynamics in the data and serves as a useful starting point for developing a credit and banking model for emerging markets.
Figure 1.3 A Visual Representation of the Model.

Households

The economy is populated with a continuum of infinitely lived households with preferences defined over consumption, $C_t(j)$ and labor effort $L_t(j)$. The objective of household is to maximize the expected value of a discounted sum of period utility function given by

$$E_0 \sum_{t=0}^{\infty} \beta^t U_t(C_t(j), L_t(j)) \quad \beta \in (0,1), U' > 0, U'' < 0$$

(1)

where $\beta$ is the discount factor and $U$ is a period utility function. We include the habit persistence according to the following specification

$$U_t(C_t(j), L_t(j)) = \zeta_t (1-b) \ln(C_t(j)-bC_{t-1}) - \frac{\zeta_{L,t}}{\psi} L_t(j)^{\psi}$$

(2)

where $C_{t-1}$ is lagged aggregate consumption and $b \in (0,1)$. $\zeta_{C,t}$ and $\zeta_{L,t}$ are preference shocks to the marginal utility of consumption and the supply of labor respectively. Note that in symmetric steady-state $C_t(j) = C_{t-1}$, the marginal utility of consumption is independent of the habit persistence parameter $b$. The aggregate consumption bundle $C_t(j)$ consists of domestically produced goods, $C_{H,t}(j)$ and an imported foreign good, $C_{F,t}(j)$ and is given by
\[ C_i(j) \equiv \left[ \frac{1}{\eta} \left( C_{H,i}(j) \right)^{\frac{\eta-1}{\eta}} + (1-\alpha) \frac{1}{\eta} \left( C_{F,i}(j) \right)^{\frac{\eta-1}{\eta}} \right]^{\frac{1}{\eta}} \]  

where \( C_{H,i}(j) \) is an index of consumption of domestic goods given by the constant elasticity of substitution (CES) function

\[ C_{H,i}(j) = \left( \int_0^1 C_{H,i}(s)^{\frac{\eta-1}{\eta}} ds \right)^{\frac{1}{\eta}} \]  

where \( s \in [0,1] \) denotes the variety of the domestic good. Parameter \( \eta \in [0, \infty] \) is the elasticity of substitution between domestic and foreign goods and \( \varepsilon_i > 1 \) is the elasticity of substitution between the varieties produced within the country. \( \alpha \in [0,1] \) can be interpreted as a measure of home bias.

We assume that households have an access to foreign financial markets or nominal contingent claims that span all relevant household specific uncertainty about future income and prices, interest rates, exchange rates and so on. As a result each household face the same intertemporal budget constraint

\[ P_i C_i(j) + e_i B_{t+1}^j (j) + P_t \tau_t(j) + P_t D_t(j) = e_i B_t^j (j) i_t^j + \int_0^1 \Pi'_t(s) ds + W_t L_t(j) \]

\[ + i_{t-1}^d P_t D_{t-1}(j) + \int_0^1 (1-\omega^b) P_t \Pi_{t-1}^b(i) di, \forall t \]

Where \( B_t^j \) is the net holding of foreign currency one period bond that matures in period \( t \), paying a gross interest rate of \( i_t^j \). Households make deposit \( D_t \) with financial intermediary.

Deposits pay the gross interest of \( i_t^d \) set by deposit banks between \( t \) and \( t+1 \).

\[ \int_0^1 \Pi'_t(s) ds \]

represents nominal profit from the ownership of domestic retail firms and \( \int_0^1 (1-\omega^b) P_t \Pi_{t-1}^b \) is the dividend earned from the ownership of banks. \( (1-\omega^b) \) is the exogenously set dividend rule. \( \tau_t \) is the lump sum tax in the economy and \( W_t \) is the nominal wage rate. \( P_t \) is the CPI index given by

\[ P_t = \left[ \alpha (P_{H,i})^{-\eta} + (1-\alpha) (P_{F,i})^{-\eta} \right]^{\frac{1}{\eta}} \]

where \( P_{H,i} \) is the domestic price index given by

\[ P_{H,i} = \left( \int_0^1 P_{H,i}(s)^{1-\varepsilon_i} ds \right)^{\frac{1}{1-\varepsilon_i}} \]
and $P_{F,i}$ is the price of the imported goods.\(^8\)

Households choose the paths of $\{C_t(j), L_t(j), D_t(j), B_{t+1}(j)\}_{t=0}^{\infty}$ to maximize expected lifetime utility given by equation (1) subject to the sequence of constraints given by equation (5) and the initial value of $B_t^i$.

Ruling out Ponzi type schemes, we get the following first order conditions

$$\frac{(1-b) \xi_{i,j}}{C_t(j) - b C_{t-1}} = \lambda_t P_t \tag{8}$$

$$\xi_{i,j} L_t(j)^{y-1} = \lambda_t W_t \tag{9}$$

where $\lambda_t$ is the lagrange multiplier associated with the budget constraint. The first order conditions are given by

$$1 = (i_t^d) E_t \left\{ \rho_{t,t+1} \frac{P_t}{P_{t+1}} \right\} \tag{10}$$

$$1 = (i_t^f) E_t \left\{ \rho_{t,t+1} \frac{P_t}{P_{t+1}} e_{t+1} \right\} \tag{11}$$

where $\rho_{t,t+1} = \beta \frac{\lambda_t}{\lambda_{t+1}} = \frac{\xi_{C,i}(C_{t+1}(j) - b C_t)}{\xi_{C,i}(C_t(j) - b C_{t-1})}$ is the stochastic discount factor.

Up to a log-linear approximation equations (10) and (11) imply, $E_t \ln(e_{t+1}/e_t) \approx i_t^d - i_t^f$. The optimum allocation of expenditure between domestic and imported goods is given by

$$C_{H,i}(j) = \alpha \left( \frac{P_{H,i}}{P_t} \right)^{-\eta} C_t(j) \tag{12}$$

$$C_{F,i}(j) = (1-\alpha) \left( \frac{P_{F,i}}{P_t} \right)^{-\eta} C_t(j) \tag{13}$$

and the demand for each variety of domestic goods is given by

$$C_{H,i}(s) = \alpha \left( \frac{P_{H,i}(s)}{P_{H,i}} \right)^{-\eta} C_{H,i}(j) \tag{14}$$

**Banks**

Banks intermediate all financial transactions between the agents in the model. We model banks as monopolistically competitive at the retail level. They hold some market power in conducting their intermediation activity, which allows them to set deposit rates and lending rates. This set up allows us to study how different degree of interest rate pass-through affects the transmission of shocks. We can think of each bank $i \in [0,1]$ in the model as composed of three parts - two retail branches and one wholesale branch. The retail branches raise

\(^8\) We assume that the price of imported goods is set in the same manner as the domestic prices in the exporting country i.e. the price of imports adjust sluggishly and is given by an equation similar to equation (46).
differentiated deposits from the household and provide differentiated loans to entrepreneurs. The wholesale unit manages the capital position of the group and in addition raises wholesale loans and wholesale deposits in the inter-bank market.

Following Gerali and others 2010) we assume that units of deposit and loan contracts bought by households and entrepreneurs are a composite CES basket of slightly differentiated products – each supplied by a branch of a bank i – with elasticities of substitution equal to \( \varepsilon_d^i \) and \( \varepsilon_l^i \), respectively. We assume that each household (entrepreneur) has to purchase a deposit (loan) contract from each single bank in order to save (borrow) one unit of resources.\(^9\) This assumption is similar to the standard Dixit-Stiglitz framework for goods markets.

Given the Dixit-Stiglitz framework, demand for an individual banks’ deposit contract depends on the interest rate charged by the bank relative to the average rates in the economy and is given by

\[
D_d(i) = \left( \frac{i_d^i(i)}{\bar{i}_d^i} \right)^{\varepsilon_d^i} D_i
\]

(15)

where \( D_i \) is the aggregate demand of deposits and \( i_d^i(i) \) is the deposit interest rate faced by each deposit bank \( i \in [0,1] \).\(^10\) \( i_d^i \) is the aggregate (average) deposit rate and is defined as

\[
i_d^i = \left( \int_0^1 (i_d^i(i))^{\varepsilon_d^i+1} \, di \right)^{-\frac{1}{\varepsilon_d^i+1}}
\]

(16)

Similarly the demand for loans facing bank \( i \) is given by

\[
L_l(i) = \left( \frac{i_l^i(i)}{\bar{i}_l^i} \right)^{-\varepsilon_l^i} L_i
\]

(17)

where \( L_l^i \) is the aggregate demand of loans and \( i_l^i(i) \) is the loan interest rate faced by each lending bank \( i \in [0,1] \).\(^11\) \( i_l^i \) is the aggregate (average) lending rate and is defined as

\[
i_l^i = \left( \int_0^1 (i_l^i(i))^{1-\varepsilon_l^i} \, di \right)^{-\frac{\varepsilon_l^i}{1-\varepsilon_l^i}}
\]

\(^9\) Though this assumption may seem unrealistic, it is just a useful modeling device to capture the existence of market power in the banking industry. A similar approach has been adopted by Benes and Lees (2007). Arce and Andres (2009) set up a general equilibrium model featuring a finite number of imperfectly competitive banks in which the cost of banking services is increasing in customers’ distance. Mandelman (2009) set up a model with segmented banking sector where collusive pricing decisions give rise to the market power.

\(^{10}\) Aggregate deposit demand is given by

\[
D_d = \left( \int_0^1 (D_d(i))^{\varepsilon_d^i} \, di \right)^{\frac{\varepsilon_d^i}{1+\varepsilon_d^i}}
\]

\(^{11}\) Aggregate loan demand is given by

\[
L_l^d = \left( \int_0^1 (L_l^d(i))^{1-\varepsilon_l^i} \, di \right)^{-\frac{\varepsilon_l^i}{1-\varepsilon_l^i}}
\[ i_t^d = \left( \int_0^1 \left( \frac{i_t^d(i)}{1+\epsilon_t^d} \right) \, di \right)^{1/\epsilon_t^d} \tag{18} \]

**Retail Banking**

Retail banking takes place in a monopolistically competitive setting. There is a continuum of two types of retail branches – deposit branch and loan branch.

**Deposit Branch**

Each deposit branch collects deposit \( D_t(i) \) from households and passes it on to the wholesale branch which pays them a rate \( i_t^d \). Also, we assume that there is a quadratic adjustment cost of intertemporally varying the deposit interest rate. This rigidity allows an interest rate spread that evolves over the cycle. We assume adjustment costs à la Rotemberg (1982), given by

\[ Ad_t^d(i) = \frac{\phi_d}{2} \left( \frac{i_t^d(i)}{i_{t-1}^d(i)} - 1 \right)^2 D_t, \]

where \( \phi_d > 0 \) is a cost adjustment parameter. The optimization problem of the saving bank is to choose the retail deposit interest rate \( i_t^d(i) \) to maximize

\[ \text{Max} E_0 \sum_{t=0}^{\infty} \beta^t [i_t^d D_t(i) - i_t^d(i) D_t(i) - Ad_t^d(i)] \]

subject to

\[ D_t(i) = \left( \frac{i_t^d(i)}{i_t^d} \right)^{\epsilon_t^d} D_t. \]

In symmetric equilibrium, the first order condition of this optimization problem gives the optimal deposit interest rate

\[ \frac{1+\epsilon_t^d}{\epsilon_t^d} i_t^d = i_t^d - \frac{\phi_d}{\epsilon_t^d} \left( \frac{i_t^d}{i_{t-1}^d} - 1 \right) i_t^d + \beta \frac{\phi_d}{\epsilon_t^d} \left( \frac{i_{t+1}^d}{i_t} - 1 \right) \frac{i_t^d}{i_{t+1}^d} \frac{D_{t+1}}{D_t} \tag{19} \]

Thus, the deposit rate is a mark down of the wholesale deposit rate and expected future gain of adjusting the deposit rate. With fully flexible rates, \( i_t^d \) is determined as a static mark-down over the wholesale deposit rate –

\[ i_t^d = \frac{\epsilon_t^d}{1+\epsilon_t^d} i_t^s \tag{20} \]

**Loan Branch**

Each retail branch obtain wholesale loan \( L_t^d(i) \) from the wholesale unit at the rate \( i_t^b \). We assume that there is a quadratic adjustment cost of intertemporally varying the lending rate. This rigidity allows an interest rate spread that evolves over the cycle. We assume adjustment costs à la Rotemberg (1982), given by
\[
Ad^d(i) = \frac{\phi \left( \frac{L^d}{L^d} - 1 \right)}{2} L^d
\]

where \( \phi > 0 \) is a cost adjustment parameter. The optimization problem of the lending bank is to choose the retail lending rate \( i^r(i) \) to maximize

\[
\text{Max}_{i^r} \sum_{t=0}^{\infty} \beta^t \left[ i^r(i) L^d(i) - i^b(i) L^d(i) - Ad^d(i) \right]
\]

subject to

\[
L^d(i) = \left( \frac{i^r(i)}{i^r} \right)^{\varepsilon^d} L^d
\]

In symmetric equilibrium, the first order condition of this optimization problem gives the optimal deposit interest rate

\[
i^r = \frac{\varepsilon^d}{\varepsilon} - 1 b - \frac{\phi \left( \frac{i^r}{i^r} - 1 \right)}{\varepsilon - 1} \frac{i^r}{i^r} + \beta \frac{\phi \left( \frac{i^r}{i^r} - 1 \right)}{\varepsilon - 1} \frac{i^r}{i^r} L^d \frac{L^d}{L^d} \]

(21)

Thus, the lending rate is a mark up over the wholesale loan rate and expected future gain of adjusting the lending rate. With fully flexible rates, \( i^r \) is determined as a static mark-up over the wholesale loan rate –

\[
i^r = \frac{\varepsilon^d}{\varepsilon - 1} b
\]

(22)

**Wholesale Branch**

Wholesale branch get the deposits from the deposit branch. In order to study the effect of non-traditional monetary policy interventions we introduce two such tools. We assume that wholesale branch meets the cash reserve ratio (CRR) and the statutory liquidity ratio (SLR) imposed by the central bank.\(^{12}\) The latter can also be thought of as an exogenously determined share of deposits in government securities that is susceptible to changes investor and bank sentiment. Central bank varies these requirements to control credit supply by changing the availability of resources available with the banks to make loans. Let \( \alpha^s \) is the CRR and \( \alpha^d \) is the SLR requirements. Then wholesale branch keep \( \alpha^s D_i(i) \) in the form of cash and keep \( R^b = \alpha^d D_i(i) \) in the form of government securities.\(^{13}\) It earns an interest of \( i^r \) on the government securities. The wholesale branch combines net worth or bank capital \( Z_i(i) \) with the remaining available deposit \( 1 - \alpha^s - \alpha^d \) \( D_i(i) \) and inter-bank loans, \( B^B(i) \), to make wholesale loans \( L^d(i) \).

Since wholesale branch can finance their loans using either deposits or bank capital they

\(^{12}\) CRR is the portion of deposits that banks are required to keep in the form of cash. SLR is the portion of bank holdings kept in the form of liquid government securities.

\(^{13}\) Since CRR does not earn any profits and SLR earns a lower profit than lending in the market.
have to obey a balance sheet identity:

\[ L_d^i = (1 - \alpha^i - \alpha^d_i)D_i(i) + B_i^{im}(i) + Z_i(i) \] (23)

As two sources of finance are perfect substitutes from the point of view of the balance sheet, we introduce some non-linearity (i.e. imperfect substitutability) in order to pin down the choices of the bank. We assume that there exists an (exogenously given) capital-to-assets (i.e. leverage) ratio \( \kappa^b \) for banks. In particular, the bank pays a quadratic cost whenever the capital-to-assets ratio \( (Z_i(i)/L_d^i(i)) \) moves away from \( \kappa^b \). This modeling choice provides us a shortcut to study the implications and costs of regulatory capital requirements and also gives bank capital a key role in determining the conditions of credit supply.

Bank capital is accumulated each period out of retained earnings according to

\[ Z_i(i) = (1 - \delta^b)Z_{i-1}(i) + \omega^b \Pi_{i-1}^b(i) - m_i \] (24)

where \( \Pi_{i-1}^b(i) \) is overall bank profits made by the three branches of bank \( i \) in nominal terms, \( (1 - \omega^b) \) summarizes the dividend policy of the bank, and \( \delta^b \) measures resources used in managing bank capital and conducting overall banking intermediation activity. \( m_i \) is a mean zero shock to the bank capital. Since we assume that bank capital is accumulated out of retained earnings, the model has in-built feedback loop between the real and the financial side of the economy. As macroeconomic conditions deteriorate, banks profits are reduced, weakening their ability to raise new capital. Depending on the nature of the shock, it may result in the reduction of amount of loans banks are willing to give, thus exacerbating the original contraction.

The dividend policy is assumed to be exogenously fixed, so that bank capital is not a choice variable for the bank. The problem for wholesale branch is to choose loans \( L_d^i(i) \), deposits \( D_i(i) \), and interbank borrowing \( B_i^{im}(i) \) so as to maximize profits subject to the balance sheet constraint given by equation (23) and \( R_i^b = \alpha^d_i D_i(i) \)

\[
\max_{L_d^i(i), D_i(i), B_i^{im}(i)} \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left[ i_t^d L_d^i(i) + i_t^b R_i^b(i) - i_t^d D_t(i) \right.
\]

\[
\left. - i_t^d B_i^{im}(i) - Z_t(i) - \frac{\phi}{2} \left( \frac{Z_t(i)}{L_d^i(i)} - \kappa^b \right)^2 Z_t(i) \right]
\]

where \( i_t^d \) - the wholesale deposit rate and \( i_t^b \) - the wholesale loan rate are taken as given.\(^{14}\) \( \phi_Z \) is the cost of bank capital adjustment parameter. In a symmetric equilibrium, the first order condition gives

\(^{14}\) Banks value the future stream of profits using the households discount factor since they are owned by households.
\[ i_{i}^b = i_i - \phi_Z \left( \frac{Z_i}{L_i^d} - \kappa^b \right) \left( \frac{Z_i}{L_i^d} \right)^2 \]  
(25)

\[ i_i^s = (1 - \alpha_i^s - \alpha_i^{d}) i_i + \alpha_i^d i_i^d \]  
(26)

The above equations state a condition that links the rate on wholesale loans to the policy rate \( i_i \) and the leverage of the banking sector \( \frac{Z_i}{L_i^d} \) and wholesale deposit rate to the policy rate, t-bill rate and reserve requirements, \( \alpha_i^s \) and \( \alpha_i^d \).

It highlights the role of bank capital and reserve requirements in determining the credit supply conditions. As long as there is a spread between lending and the policy rate - the bank would like to make as many loans as possible, increasing the leverage and thus profit per unit of capital. On the other hand, when leverage increases, the capital-to-asset ratio moves away from \( \kappa^b \) and banks pay a cost, which reduces profits. So, banks problem is to choose an optimal level of loans such that the marginal cost of reducing the capital-to-asset ratio exactly equals the spread between (wholesale) deposit and lending rate.

The spread between the wholesale lending rate and the policy rate is inversely related to the overall leverage of the banking system - in particular, when banks are scarcely capitalized and capital constraints become more binding (i.e. when leverage increases) margins become tighter.

Overall profits of bank \( i \), are the sum of earnings from the wholesale unit and the retail branches. After deleting the intra-group transactions, profits is given by

\[ \Pi_i^b = i_i^s(i) L_i^d(i) - i_i^d(i) D_i(i) - A d_i^d(i) - A d_i^d(i) - \phi_Z \left( \frac{Z_i(i)}{L_i^d(i)} - \kappa^b \right) Z_i(i) \]  
(27)

**Production Sector**

**Entrepreneurs**

We model the behavior of entrepreneurs as proposed by Bernanke, Gertler and Gilchrist (1999). We follow the modeling framework of Gertler, Gilchrist and Natalucci (2007) and Elekdag, Justiniano and Tchakarov (2005) while introducing financial accelerator in an open economy context. Entrepreneurs combine labor hired from households with capital purchased from the capital producers, to produce intermediate goods in a perfectly competitive setting. They are risk neutral and have a finite horizon for planning purposes. The probability that an entrepreneur will survive until
the next period is \( \nu_t \), so that the expected live horizon is 
\[ \frac{1}{1 - \nu_t}. \]

The number of new entrepreneurs entering the market each period is equal to the number of entrepreneurs exiting, implying a stationary population. To get started, new entrepreneurs receive a small transfer of funds from exiting entrepreneurs.

At the end of each period \( t \), entrepreneurs purchase capital \( K_{t+1} \), to be used in the subsequent period at a price \( q_t \). They finance capital acquisition partly through their net worth available at the end of period \( t \), \( n_{t+1} \), and partly through borrowing domestically and through raising foreign currency denominated debt. Total borrowing \( B_t \) is given by

\[
B_t = q_t K_{t+1} - n_{t+1}
\]

where \( q_t \) is the real price per unit of capital. Fraction of loan raised domestically \( B^d_t \) is exogenous to the model and is given by \( \sigma \). Thus, \( B^d_t = \sigma (q_t K_{t+1} - n_{t+1}) \) and \( B^a_t = (1 - \sigma)(q_t K_{t+1} - n_{t+1}) \) where \( B^a_t \) is the amount of loans raised abroad. Entrepreneurs use units of \( K \) capital and \( L \) units of labor to produce output \( Y_t \), using a constant returns to scale technology

\[
Y_t \leq \theta_t K_t^\varphi L_t^{1-\varphi}, \quad \varphi \in (0,1)
\]

where \( \theta_t \) is a stochastic disturbance to total factor productivity. Entrepreneur maximizes profits by choosing \( K_t \) and \( L_t \) subject to the production function given by equation (29).

First order conditions for this optimization problem are

\[
W_t = (1 - \varphi)P^w_{H,t} \frac{Y_t^w}{L_t}
\]

\[
r_{K,t} = \frac{P^w_{H,t}}{P_t} (\varphi) \frac{Y_t^w}{K_t}
\]

where \( P^w_{H,t} \) is the price of the wholesale good and \( r_{K,t} \) is the marginal productivity of capital.\(^{16}\)

The expected marginal real return on capital acquired at \( t \) and used in \( t + 1 \) yields the expected gross return \( E_t (1 + r^k_{t+1}) \), where

\[
E_t (1 + r^k_{t+1}) = E_t \left[ \frac{r_{K,t+1} + (1 - \delta)q_{t+1}}{q_t} \right]
\]

\(^{15}\) This assumption ensures that entrepreneur’s net worth (the firm equity) will never be enough to fully finance the new capital acquisition.

\(^{16}\) Since the firms are perfectly competitive, \( P^w_{H,t} = MC^w_t \).
and \( \delta \) is the rate of depreciation of capital and \( r_{K,t+1} \) is the marginal productivity of capital at \( t+1 \).

Following Bernanke, Gertler and Gilchrist (1999), we assume that there exists an agency problem which makes external finance more expensive than internal funds. While entrepreneurs costlessly observe their output, which is subject to random outcomes, banks can not verify output outcomes costlessly. After observing the outcome, entrepreneurs decide whether to repay their debt or to default. If they default, banks audit the loan and recover the outcome less the monitoring costs. This agency problem makes loans riskier and banks charge a premium over the lending rate. Thus, entrepreneurs’ marginal external financing cost is the product of the gross premium and the gross real opportunity cost of funds that would arise in the absence of capital market frictions.

Therefore, the expected marginal cost of borrowing, \( E_i f_{t+1} \), is given by

\[
E_i f_{t+1} = (1 + \Gamma) \left\{ \Theta \left( \frac{n_{t+1}}{q_t K_{t+1}} \right) \sigma E_i \left[ \frac{i}{\pi_{t+1}} \right] + \Theta \left( \frac{n_{t+1}}{q_t K_{t+1}} \right) (1 - \sigma) E_i \left[ \frac{i}{\pi_{t+1} \cdot RER_{t+1}} \right] \right\} 
\]

\( \Theta' < 0 \) and \( \Theta(1) = 1 \)

where \( \Theta \) is the gross finance premium which depends on the size of the borrower’s equity stake in the project (or, alternatively, the borrowers’ leverage ratio). \( \Gamma \) is the shock to the cost of borrowing, \( \pi_t = \frac{P_t}{P_{t-1}} \), is the gross domestic inflation and \( \pi_t^* = \frac{P_t^*}{P_{t-1}} \), is the gross world inflation. \( RER_t \) is the real exchange rate defined as \( RER_t = \frac{e_t P_t^*}{P_t} \).

We characterize the risk premium by \( \Theta \) by \( \left( \frac{n_{t+1}}{q_t K_{t+1}} \right)^\sigma \), where \( \sigma \) represents the elasticity of external finance premium with respect to a change in the leverage position of entrepreneurs. As \( \left( \frac{n_{t+1}}{q_t K_{t+1}} \right) \) falls, entrepreneur relies on uncollateralized borrowing (higher leverage) to a larger extent to fund his project. Since this increases the incentive to misreport the outcome of the project, the loan becomes riskier and the cost of borrowing rises. Entrepreneurs’ demand for capital depends on the expected marginal return and the expected cost of borrowing. Thus, demand for capital satisfies the following optimality condition

\[
E_i (1 + f_{t+1}^i) = (1 + \Gamma) \left\{ \Theta \left( \frac{n_{t+1}}{q_t K_{t+1}} \right) \sigma E_i \left[ \frac{i}{\pi_{t+1}} \right] + \Theta \left( \frac{n_{t+1}}{q_t K_{t+1}} \right) (1 - \sigma) E_i \left[ \frac{i}{\pi_{t+1} \cdot RER_{t+1}} \right] \right\} 
\]

\( ^{17} \) We assume that law of one price holds for each of the differentiated goods.
Above equation provides the foundation for the financial accelerator. It links entrepreneurs’ financial position to the marginal cost of funds and, hence to the demand for capital. Also, movements in the price of capital, $q_t$, may have significant effects on the leverage ratio. In this way the model captures the link between asset price movements and collateral stressed in the theory of credit cycles (Kiyotaki and Moore, 1997). At the beginning of each period, entrepreneurs collect their returns on capital and honor their debt obligations. Aggregate entrepreneurial net worth evolves according to

$$n_{t+1} = n_t + (1 - v_t)H_t$$  \hspace{1cm} (35)$$

where $V_t$ is the net worth of the surviving entrepreneurs carried over from the previous period, $1 - v_t$ is the fraction of new entrepreneurs entering and $H_t$ (which is exogenous in the model) are the transfers from exiting to newly entering entrepreneurs. $V_t$ is given by

$$V_t = \left[ (1 + r^K_t)q_{t-1} - (1 + \pi_t) \Theta \left( \frac{n_t}{q_{t-1}K_t} \right) \left[ \frac{i_{t-1}}{\pi_t} \right] (\theta(q_{t-1}K_t - n_t)) \right]$$

$$- (1 + \pi_t) \Theta \left( \frac{n_t}{q_{t-1}K_t} \right) E_t \left[ \frac{i_{t-1}}{\pi_t} \frac{\text{RER}_{t-1}}{\text{RER}_t} \right] (1 - \theta)(q_{t-1}K_t - n_t)) \right]$$  \hspace{1cm} (36)$$

As equations (35) and (36) suggest, the principal source of movements in net worth stems from unanticipated movements in returns and borrowing costs. In this regard, unforecastable variations in asset prices, $q_t$, is the main source of fluctuations in $(1 + r^K_t)$. On the cost side, unexpected movements in inflation and exchange rates are the major sources of fluctuations in the net worth. An unexpected deflation or depreciation, for example, reduces entrepreneurial net worth, thus enhancing the financial accelerator mechanism. Entrepreneurs going out of business at time $t$ consume and transfer some funds to new entrepreneurs out of the residual equity $(1 - v) V_t$. Thus consumption by entrepreneurs are given by

$$C_t = (1 - v)(V_t - H_t)$$  \hspace{1cm} (37)$$

**Capital Producers**

Capital producers combine the existing capital stock, $K_t$, leased from the entrepreneurs to transform an input $I_t$, gross investment, into new capital $K_{t+1}$ using a linear technology. We

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18 Though the behavior described above is true for an individual entrepreneur, we appeal to the assumptions in Bernanke, Gertler and Gilchrist (1999) that permit us to write it as an aggregate condition. See Bernanke et al. (1999) and Carlstrom and Fuerst (1997) for details. It implies that gross finance premium may be expressed as a function of aggregate leverage ratio, i.e. it is not entrepreneur specific.

19 This set up follows Bernanke et al. (1999) and assumes that capital producers rent the capital stock from entrepreneurs and use it to produce new capital. Since this takes place within the period we assume that the rental rate is zero.
assume that capital producers face a quadratic adjustment costs given by
\[
\left(\frac{\kappa}{2} \left( \frac{L}{K_t} - \delta \right) \right)^2 K_t.
\]
where \( \kappa \) is the capital adjustment cost parameter. The aggregate capital stock evolves according to
\[
K_{t+1} = (1 - \delta)K_t + \zeta_{I,t}I_t - \left( \frac{\kappa}{2} \left( \frac{L}{K_t} - \delta \right) \right)^2 K_t
\]
where \( \zeta_{I,t} \) is a shock to the marginal efficiency of investment (Greenwood et al. 1988).
Gross investment consists of domestic and foreign final good and we assume that it is the same aggregation function as the consumption basket
\[
I_t = \left[ \alpha^n \left( \frac{P_{H,t}}{P_t} \right) \right]^{\eta} + \left[ (1 - \alpha)^n \left( \frac{P_{F,t}}{P_t} \right) \right]^{\eta}
\]
Optimal demand for domestic and imported investment is given by
\[
I_{H,t} = \alpha \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} I_t
\]
\[
I_{F,t} = (1 - \alpha) \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} I_t
\]
Price of investment is the same as the domestic price index given by equation (6).
Capital producing firms maximize expected profits
\[
\text{Max}_t E_t \left\{ q_t \left[ \zeta_{I,t}I_t - \left( \frac{\kappa}{2} \left( \frac{L}{K_t} - \delta \right) \right)^2 K_t \right] - I_t \right\}
\]
and the first order condition for the supply of capital is given by
\[
q_t \left[ \zeta_{I,t} - \kappa \left( \frac{L}{K_t} - \delta \right) \right] = 1
\]

Retailers
There is a continuum of retailers \( s \in [0,1] \). They purchase wholesale goods at a price equal to the nominal marginal costs, \( MC_t^W \) (the marginal cost in the entrepreneurs’ sector) and differentiate them at no cost.\(^\text{20}\) They sell their product in a monopolistically competitive domestic and export market. Final domestic good, \( Y_t^W \), is a CES composite of individual retail goods

\(^{20}\) Entrepreneurs sell their goods in a perfectly competitive market so \( P_{H,t}^W = MC_t^W \). Retail sector is defined only to introduce nominal rigidity into the economy. Since they differentiate goods costlessly, the marginal cost of producing final goods is same as \( MC_t^W \).
Corresponding price of the composite consumption good, $P_{H,t}$, is given by equation (7). Demand facing each retailer can be written as

$$Y_{H,t} = \left( \int_0^1 Y_{H,t}(s)^{\frac{e_i}{\sigma_i}} \, ds \right)^{\frac{\sigma_i}{e_i}}$$  \hspace{1cm} (43)$$

For simplicity we assume that the aggregate export demand function is given by

$$Q_t^X = \left( \frac{P_{X,t}}{P_t} \right)^{-\zeta_t}, \quad \zeta_t > 0$$ \hspace{1cm} (44)$$

where $P_{X,t} = eP_{H,t}$ is the price of exports, $P^*$ is the world price index and $Q^X_t$ is the total exports. $\zeta_t$ is the price elasticity of exports.

**Price Setting by Retailers**

Following Ireland (2001) and Rotemberg (1982), there is sluggish price adjustment to make the intermediate goods pricing decision dynamic. This ensures that monetary policy has real effects on the economy. Following Julliard et al. (2004), we assume that retailers face an explicit cost of price adjustment measured in terms of intermediate goods and is given by

$$\frac{\partial_{\Delta}}{2} \left[ \frac{P_{H,t}(s)/P_{H,t-1}(s)}{\pi} - 1 \right]^2 (Q^d_t + Q^X_t)$$

where $Q^d_t$ is the total domestic demand, $\partial_{\Delta} \geq 0$ is the parameter determining the cost of price adjustment relative to last period’s price level and $\pi$ is the steady state inflation. Following Saxegaard (2006b), real profits are given by

$$\Pi_t[P_{H,t}(s), P_{x,t}(s)] = \left[ \frac{P_{H,t}(s)}{P_t} - \frac{MC^W_t}{P_t} \right] \left[ \frac{P_{H,t}(s)}{P_{H,t}} \right]^{-\epsilon} Q^d_t + \left[ \frac{e_t P_{x,t}(s)}{P_t} - \frac{MC^W_t}{P_t} \right] \left[ \frac{P_{x,t}(s)}{P_{x,t}} \right]^{-\epsilon} Q^X_t$$

$$- \frac{\partial_{\Delta}}{2} \left[ \frac{P_{H,t}(s)/P_{H,t-1}(s)}{\pi} - 1 \right]^2 (Q^d_t + Q^X_t)$$

where $e_t$ is the nominal exchange rate, expressed as the domestic currency price of foreign currency. Note also that we allow for a shock to the elasticity of substitution between differentiated goods $\epsilon_i$, which determines the size of the markup of intermediate good firms. Alternatively, the shock to $\epsilon_i$ can be interpreted as a cost-push shock of the kind introduced into the New Keynesian model by Clarida, Gali and Gertler (1999).

The optimal price setting equation for domestic good (non-tradable good) can then be

\footnote{An increase in $e_t$ implies depreciation of the domestic currency.}
written as\(^{22}\)

\[
P_{H,t} = \frac{\varepsilon_t}{\varepsilon_t - 1} MC_w^i - \frac{\vartheta_d}{\varepsilon_t - 1} P_t \pi_{H,t} \left[ \frac{\pi_{H,t}}{\pi} - 1 \right] + \frac{\vartheta_d}{\varepsilon_t - 1} P_t E_t \left\{ \rho_{t,t+1} \frac{Y_{H,t+1}}{\pi_{H,t+1}} - \frac{\pi_{H,t+1}}{\pi} - 1 \right\}
\]

(46)

where \(\pi_{H,t} = P_{H,t} / P_{H,t-1}\) is the domestic price inflation.

We have used the fact that all retailer firms are alike to impose symmetry and we assume that the law of one price holds in the export market so that \(P_{X,t} = P_{H,t} / e_t\).

Above equation reduces to the well known result that prices are set as a markup over marginal costs if the cost of price adjustment, \(\vartheta_d = 0\). In general however, the goods price will follow a dynamic process and the firm’s actual markup will differ from, but gravitate towards the desired markup. Profits from retail activity are rebated lump-sum to households (i.e. households are the ultimate owners of retail outlets).

**Central Bank and Government**

**Central Bank**

We assume that the central bank adjusts the interbank rate, \(i\), in response to deviations in inflation and output from their steady state values. The monetary policy evolves according to the following Taylor-type-policy rule

\[
\log \left( \frac{i_t}{i} \right) = \rho_i \log \left( \frac{i_{t-1}}{i} \right) + \rho_y \log \left( \frac{Y_t}{Y} \right) + \rho_{\pi} \log \left( \frac{\pi_t}{\pi} \right) + \varepsilon_{i,t}
\]

(47)

where \(\rho_{\pi}\) and \(\rho_y\) are the weights on inflation and output gap assigned by the policy makers.\(^{23}\) \(\rho_i\) represents the Central Banker’s preference for interest rate smoothing. \(Y, \pi\) and \(i\) are the steady state values of output, inflation and nominal interest rate. \(\varepsilon_{i,t}\) is a monetary policy shock to capture unanticipated increase in the nominal interest rate.

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\(^{22}\) We assume that price of imported goods are set in the similar function. So the price setting equation for the price of imported good is given by a similar expression with \(\pi_{M,t}\), import price inflation, in place of \(\pi_{H,t}\) and \(\vartheta_m\) in place of \(\vartheta_d\).

\(^{23}\) We include an interest rate smoothing parameter in our monetary policy rule as the benefits of such smoothing are well documented in the literature (see, e.g., Lowe and Ellis, 1997; Sack and Wieland, 1999). Various authors have argued that moving interest rates in small steps increases its impact on the long-term interest rate; it also reduces the risks of policy mistakes and prevents large capital losses and systemic financial risks. Mohanty and Klau (2004) find that all emerging market central banks put substantial weight on interest rate smoothing. Clarida et al. (1998) find that central banks of advanced economies also put a large weight on interest rate smoothing.
Government

The fiscal authority is assumed to purchase an exogenous stream of the final good $G_t$, which is financed by a levying lump-sum tax on households, and issuing securities held by the banks. For simplicity we assume that the fiscal authority has no access to international capital markets. Its period by period budget constraint is given by

$$G_t + \left(1 + i_{t-1}^b \right) R^b_{t-1} = \tau_t + R^b_t$$ (48)

Government buys both domestic and foreign final goods and we assume that it is the same aggregate function as the consumption basket

$$G_t \equiv \left[ \alpha (G_{H,t})^{\frac{\eta}{\eta-1}} + (1-\alpha) (G_{F,t})^{\frac{\eta}{\eta-1}} \right]^{\frac{\eta-1}{\eta}}$$ (49)

Optimal demand for governments’ domestic and imported consumption is given by

$$G_{H,t} = \alpha \left( \frac{P_{H,t}}{P_t} \right)^{-\eta} G_t$$ (50)

$$G_{F,t} = (1-\alpha) \left( \frac{P_{F,t}}{P_t} \right)^{-\eta} G_t$$ (51)

Market Clearing and Aggregation

Domestic households, exiting entrepreneurs, capital producers, government and rest of the world buy final goods from retailers. The economy wide resource constraint is given by

$$Y_{H,t} = C_{H,t} + C^e_{H,t} + I_{H,t} + G_{H,t} + Q^X_{t} = Q^d_{t} + Q^X_{t}$$ (52)

where

$$Q^d_{t} = C_{H,t} + C^e_{H,t} + I_{H,t} + G_{H,t}$$ (53)

The national income accounting equation is given by

$$P_t*Z_{t} = P_t(C_t + C^e_t + I_t + G_t) + P_{X, t}Q^X_t - P_{F, t}Q^M_t + \frac{Q^d_t}{2} \left[ \frac{P_{H,t}}{P_{H,t-1}} \right] - 1 \right]^{2} P_{H,t} Y_{H,t}$$

where $Q^M_t$ is the total imports and $Z_{t}$ is the real GDP.

Markets for loan and deposits clear –

$$D_t = L^d_t = B^d_t$$ (54)

Funds in the inter-bank market mush implicitly balance at the end of each period:

$$\int_0^1 B^m_t (i) di = B^m_t = 0$$ (55)

The model allows for non-zero holdings of foreign currency bonds by households and foreign currency denominated debt by entrepreneurs. In particular, it is well known (see inter alia Schimtt-Grohe and Uribe, 2003) that unless adjustments are made to the standard model,

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24 Following Bernanke et al. (1999) we ignore monitoring costs in the general equilibrium.
the steady state of an small open-economy model with foreign currency bonds will depend upon initial conditions and will display dynamics with random walk properties. In particular, if the domestic discount rate exceeds the real rate of return on foreign currency bonds, then domestic holdings of foreign currency bonds will increase perpetually. Beyond the obvious conceptual problems of such an outcome our analysis is constrained by the fact that the available techniques used to solve non-linear business cycle models of the type considered here are only valid locally around a stationary path.

Fortunately, a number of modifications to the standard model are available which enable us to overcome this issue. In this paper, we follow Schmitt-Grohe and Uribe (2003) and specify a foreign debt elastic risk-premium whereby holders of foreign debt are assumed to face an interest rate that is increasing in the country’s net foreign debt. In particular, if, the interest rate at which households and entrepreneurs can borrow foreign currency equals the exogenous world interest rate plus a spread that is a decreasing function of economy’s net foreign asset position:

\[ i_t' = i_t^* - \chi_d \left[ \left( B_t^f + L_t^f \right) / P^* - \varrho \right] - \left( B_t^f + L_t^f \right) / P^* \right] / \Omega \]  

where \( \chi_d \) is a parameter which captures the degree of capital mobility in the market for foreign-currency borrowing and lending by households and \( \Omega \) is the steady-state value of exports. As in Schmitt-Grohe and Uribe (2003) we include the steady-state level of debt so that the risk-premium is nil in steady state. Note that under perfect capital mobility (\( \chi_d = 0 \)), the country would face an infinite supply or demand of foreign capital and the model would not have a well-defined steady state. As Kollmann (2002) points out, the model in this case becomes a version of the permanent income theory of consumption, with non-stationary consumption and net assets.

**Specification of the Stochastic Processes**

Our model includes fifteen structural shocks: three shocks to technology and preferences (\( \theta_t, \zeta_{C_t}, \zeta_{L_t} \)), three foreign shocks to world interest rates, world inflation, and the price elasticity of exports (\( \pi_t^*, i_t^*, \zeta_t \)), two shocks to investment efficiency and firms’ markup (\( \xi_{I_t}, \xi_{C_t} \)), two financial shocks to the cost of borrowing by entrepreneurs and the survival rate of entrepreneurs (\( \Gamma_t, \nu_t \)), a monetary policy shock, a government spending shock (\( \varepsilon_{i_t}, G_t \)), a shock to CRR (\( \alpha_t' \)), a shock to SLR(\( \alpha_t^d \)) and a shock to back capital (\( m_t \)). Apart from monetary policy shock, \( \varepsilon_t \), which is a zero mean i.i.d. shock with a standard deviation \( \sigma_t \), the other structural shocks follow AR(1) processes:

\[ x_t = (1 - \rho_x) x + \rho_x x_{t-1} + \varepsilon_{st} \]  

where \( x_t = \left\{ \theta_t, \zeta_{C_t}, \zeta_{L_t}, \pi_t^*, i_t^*, \zeta_t, \Gamma_t, \nu_t, \xi_{I_t}, \xi_{C_t}, \alpha_t', \alpha_t^d, \varepsilon_t, \varepsilon_{i_t}, m_t \right\} \), \( x \geq 0 \) is the steady-state value of \( x_t \), \( \rho_x \in (-1,1) \), and \( \varepsilon_{st} \) is normally distributed with zero mean and standard deviation \( \sigma_{st} \).
Calibration

Parameter selection for the model is a challenging task. There is no consensus on the values of some parameters, and for the banking parameters no corresponding estimates are available in the literature. Moreover, most of the parameters used in the literature are based on micro data from advanced countries. Hence, our approach is three pronged. We calibrate the parameters in the model that determine the steady state based on findings from previous studies on emerging markets and historical data for the Philippines. For calibrating the parameters which determine the dynamic properties of the model away from the steady state we use the values estimated in Anand et al (2010) for an Asian emerging market. While for banking sector parameters we calibrate them to match historical averages.

The appropriate value of the Frisch elasticity ($1/\psi$) is both important and controversial. The range of values used in the literature goes from 0.25 to 1. For our benchmark case we assume it to be 0.66 ($\psi = 1.5$). The substitution elasticity between imported and domestically produced goods is set at 1.5 (Saxegaard, 2006a), while the elasticity of substitution of exports, $\zeta$, is set to 4.89, a value consistent with the steady state export to GDP ratio.

Following Christensen and Dib (2006), the steady state leverage ratio of entrepreneurs, $K/N$, is set to 0.5. The probability of entrepreneurial survival to next period, $\nu$, is set at 0.98. Following Anand et al. (2010) we set elasticity of external finance premium with respect to firm leverage $\sigma$ equal to 0.0566.

For calibrating parameters which determine the dynamic properties of the model we follow the estimates of Anand et al. (2010). The habit persistence parameter, $b$, is set to 0.4986. Price adjustment costs of domestic goods and price adjustment costs of imported goods are set to 118.22 and 100.043 respectively. Capital cost adjustment cost is set equal to 23.008. Monetary policy parameters are chosen as $\rho_i = 0.8$, $\rho_z = 2$, $\rho_Y = 0.01$ which are in the range of values commonly used in the literature.

For the banking parameters, no corresponding estimates are available in the literature. The parameters $\varepsilon^d$ and $\varepsilon^l$ that measure the degree of monopoly power of deposit and lending banks are set equal to 31.12 and 2.51, respectively. These values are chosen to match the historical averages of deposit and loan rates, $i^d$ and $i^l$. The parameter $\delta^b$ is set at the value 0.035, that ensures that the steady state value ratio of bank capital to total loans is exactly 0.10. We follow the estimates of Gerali et al (2010) for setting the adjustment cost.

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25 Christiano, Eichenbaum and Evans (1996) estimate it to be 0.25 while Rotemberg and Woodford (1997) estimate it to be 0.40. Blundell and MaCurdy (1999) estimate the intertemporal elasticity of labor supply to be in the range of [0.5, 1].

26 This is slightly below the estimate of 0.066 for Korea in Elekdag et al. (2005) and somewhat higher than estimate in Dib et al. (2008) for Canada.

27 Steady state capital to loan ratio is set to 0.1 which is consistent with the regulatory capital requirements for banks in the Philippines (slightly higher than imposed by Basel II).
parameters for interest rates and bank capital to loan ratio. Cost of adjusting interest rates, $\phi_r$, and $\phi_i$ are set equal to 20 while the cost of bank capital adjustment, $\phi_z$ is set equal to 10.

We calibrate the shocks’ process parameters using values estimated in Anand et al. (2010). The parameter of credit tightening process is calibrated using the estimated values in Gerali et al. (2010). Since there are no parameter estimates available in literature on non-monetary policy interventions, we choose the values of AR(1) coefficients at 0.99.\(^{28}\)

**D. Impulse Response**

The objective of this paper is to study the monetary transmission mechanism in the presence of financial frictions and financial intermediation. We are also interested in understanding how shocks in the financial sectors are transmitted to the real economy and to study the transmission mechanism of non-standard monetary policies. In comparison to traditional DSGE models, our model has two additional channels for the transmission of shocks – the financial accelerator channel (credit demand channel) and the banking channel (credit supply channel). Our aim is to study how these channels affect the transmission of shocks.

A useful way to illustrate the importance of financial accelerator is to consider the impulse response functions when the financial accelerator is present and when it is not. Therefore, we analyze the impulse responses of key macroeconomic variables to the structural shocks in two models: (1) the full model with banking sector and financial frictions (baseline hereafter), and (2) a model with only banking sector (no-FA model, hereafter).\(^{29}\)

In order to understand the role of banking sector, we compare our baseline model against a number of models where we shut down one feature of the model at a time: (1) a model where we shut down the bank capital channel; i.e. a model with a simplified balance-sheet for banks, including only deposits on the liability side (no-BK model, hereafter)\(^{30}\); (2) a model where we also remove stickiness in bank interest rate setting and allow for flexible rates (no-BK-FR model, hereafter);\(^ {31}\) and (3) a model with perfectly competitive banks, i.e. a single interest rate model with financial frictions (no-B model, hereafter).\(^ {32}\) Strictly speaking

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\(^{28}\) We do a simple OLS to get this co-efficient.

\(^{29}\) no-FA model is obtained by setting the elasticity of the external finance premium with respect to firm leverage, $\sigma$ equal to zero, but keeping all other parameters same as in the baseline model.

\(^{30}\) To obtain no-BK model, we set the cost of bank capital adjustment, $\phi_z$ equal to zero and rebate the banking profit to households in a lump-sum fashion.

\(^{31}\) To get the no-BK-FR model, we set the costs to change rates $\phi_r$ and $\phi_i$ equal to zero in the no-BK model model.

\(^{32}\) We set $\alpha^d = \alpha^l = 0$ in the no-BK-FR model. Then we set the elasticities of loan and deposit, $\varepsilon^l$ and $\varepsilon^d$ (continued)
even though we can not compare the impulse responses of our baseline model with that of no-B model, it is instructive to plot them to understand how the presence of banks affect the business cycle.

We use a monetary policy shock and productivity shock to explore the effects of financial frictions and financial intermediation on the transmission of shocks. We then look at a shock to bank capital (which can be considered as reflecting tightening credit conditions) to understand how shocks originating in the credit market affect real variables. To analyze non-standard monetary policy transmission mechanism, we focus on shocks to cash reserve ratio and shocks to the statutory liquidity ratio.

**Monetary Policy Shock**

The transmission of monetary shock is studied by analyzing the impulse responses to a 100 bps increase in the policy rate \(i_t\). Due to the presence of multiple channels, the overall effect on the transmission mechanism of monetary policy could in principle be ambiguous (Gerali et al. 2010). In order to understand the importance of financial frictions we plot the responses of baseline and no-FA model in Figure 1.4.

Figure 1.5 plots the responses of baseline, no-BK, no-BK-FR and no-B model to see how the presence of banking sector impinges on the transmission of shock. Each variable’s response is expressed as the percentage deviation from its steady state, with the exception of rate variables, which are in percentage points.

In all these models, increase in the nominal interest rate raises the cost of domestic borrowing for consumers and therefore leads to a contraction in consumption. It also raises the demand for domestic bonds, and thus appreciates the domestic currency, while the net worth of entrepreneurs declines because of the declining return to capital and higher real interest costs associated with existing debt (debt-deflation effect). Output contracts both as a result of decreased domestic demand and a result of decreased competitiveness following the appreciation of the real exchange rate. The contraction in demand in turn leads to a fall in inflation. In the baseline model, bank loan rates and deposit rates increase less than the policy rate reflecting the imperfect pass-through of lending rates.

As evident from Figure 1.4, presence of financial frictions results in the amplification of the shock. Reduction in output, consumption, investment, net worth and capital is much larger under the baseline model as compared to the no-FA model. In the presence of a financial accelerator, the external finance premium increases as a result of the decline in the net worth and rising leverage. This pushes up the real borrowing cost for entrepreneurs, putting downward pressure on investment and the price of capital which further reduces the net worth. This reduction in net worth leads to a further increase in the cost of borrowing (the premium goes up), thus reducing capital, investment and output further (second round equal to infinity. The steady state values of the two models differ as the effective lending rate and deposit rate faced by the agents are not the same. Also, absence of banks implies that there is no CRR or SLR requirement.
This mechanism amplifies the magnitude and the persistence of transitory monetary policy shocks as evident from the impulse responses.

**Figure 1.4: Impulse Responses to 100 Bps Contractionary Monetary Policy Shock (Baseline model and no-FA model)**

Each variable's response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. no-FA model is obtained by setting the elasticity of the external finance premium with respect to firm leverage, $\sigma$, equal to zero, but keeping all other parameters same as in the baseline model. So it represents a model without financial frictions.
Figure 1.5 gives an indication of how the presence of banking sector may affect the transmission of monetary shock. Comparing no-B model with no-BK-FR model highlights the role of imperfect competition in the credit market. As we can see, market power of banking system increases the volatility of real variables. Market power of banks result in higher lending rates (as lending rate is a mark-up over the policy rate) increasing the cost of borrowing for the firms. Due to financial accelerator, external finance premium goes up, reducing the net worth further and forcing the firms to borrow more from banks at an increasingly higher cost. This mechanism results in the amplification of the monetary shock. Our result is similar to Mandelman (2009), where market power of banks result in the amplification of the shocks.

However, when we compare the baseline model with no-B model, we find that the presence of banking sector attenuates the response of monetary shock. This result is driven by the stickiness in interest rate setting, which prevents banks to fully pass on the policy rate increase to retail rates. Borrowing costs faced by the firms is lower than no-B case and therefore response of output, investment and capital is muted. Thus, the presence of banking sector with sticky interest rates has a dampening effect of policy shock on output, investment, capital and net worth. Gerali et al. (2010) has also found similar attenuating effect of the banking system in the presence of sticky bank rates.

Presence of bank capital in our model seems to have virtually no effect on the dynamics of the real variables. This partly reflects the use of rather small value of the capital cost adjustment parameter in this exercise. As an example, our calibration implies that a reduction of the capital-to-asset ratio by half (from its steady state value of 10%) would increase the spread between wholesale loan rates and the policy rate by only 20 basis points.

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33 As no-BK-FR model add a simplified banking sector to the no-B model. In no-BK-FR model, only bank’s market power channel is present (as both the bank capital channel and sticky interest rates channel are shut).
Figure 1.5: Impulse Responses to 100 Bps Contractionary Monetary Policy Shock (Baseline model, no-BK model, no-BK-FR model and no-B model)

Note: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. In no-BK model we shut down the bank capital channel. We set the cost of bank capital adjustment, $\phi_Z$ equal to zero and rebate the banking profit to households in a lump-sum fashion. no-BK-FR model, also shuts down the sticky interest rate channel. It is obtained by setting $\phi_i$ and $\phi_l$ equal to zero in the no-BK model model. To obtain no-B model, we set $\alpha' = \alpha^d = 0$ and the elasticities of loan and deposit, $e^l$ and $e^d$ equal to infinity. no-B model is a single interest rate model with financial frictions but no banking sector. The steady state values of the two models differ as the effective lending rate and deposit rate faced by the agents are not the same. Since the steady-state under the two models is different, this plot is only instructive.
Technology Shock

The transmission of a technology shock is studied by looking at the impulse responses coming from the same set of models described in the previous subsection. Figure 1.6 plots the responses of baseline and no-FA model. Figure 1.7 plots the responses of baseline, no-B and no-BK-FR model to see how the presence of banking sector impinges on the transmission of shock. Each variable’s response is expressed as the percentage deviation from its steady state, with the exception of rate variables, which are in percentage points.

In all these models, negative technology shock decreases the return to capital and thus leads to decrease in investment and output. At the same time, negative productivity shock increases firms’ marginal costs and thus increases inflation. The lower return to capital, and higher inflation, has opposite effects on net worth, but in our model the negative impact of the lower capital return to capital dominates. Higher inflation and domestic interest rates result in real appreciation thereby decreasing the demand for exports, which lead to further output contraction. Monetary policy responds to the increase in inflation by raising the policy rate, and therefore decreasing loans, aggregate demand and output further.

Figure 1.6 shows that the financial accelerator has less of an impact following a negative shock to technology. When the financial accelerator is active, the fall in net worth pushes up the risk premium faced by entrepreneurs and leads to a larger response of investment and capital. While output is somewhat more volatile when the financial accelerator is present, the impact is significantly less than following a shock to monetary policy.

Figure 1.7 gives an indication of how the presence of banking sector may affect the transmission of productivity shock. Comparing no-B model with no-BK-FR model indicates that the presence of monopolistic banking system amplifies the propagation of the shock. Similar to monetary policy shock, market power of banks result in higher lending rates (as banks apply a mark-up to the inter-bank rate) resulting in higher borrowing costs for the firms which in the presence of financial accelerator leads to an increase in external finance premium, thus reducing capital, investment and output further. This mechanism results in the amplification and persistence of the negative shock. Again our result is similar to that of Mandelman (2009).

However, in the presence of sticky interest rates, banking sector attenuates the response of the technology shock (comparing baseline with no-B model). Since bank rates are sticky, increase in the retail rates are much less than the policy rate. Thus the borrowing cost for firms increase by less in the presence of sticky interest rate setting banks. Thus, the presence of banking sector with sticky interest rates has a dampening effect of policy shock on output, investment, capital and net worth.

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34 Similar to monetary policy shock, bank capital have virtually no effect on real variables, so we do not present the impulse responses.
Figure 1.6: Impulse Responses to a 1% Negative Shock to Technology (Baseline model and no-FA model).

Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. no-FA model is obtained by setting the elasticity of the external finance premium with respect to firm leverage, \( \sigma \), equal to zero, but keeping all other parameters same as in the baseline model. So it represents a model without financial frictions.
Figure 1.7: Impulse Responses to a 1% Negative Shock to Technology
(Baseline model, no-B model and no-BK-FR model)

NOTE: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Baseline model represents the complete model with financial frictions and banking sector. To obtain no-BK-FR model first we shut down the bank capital channel. We set the cost of bank capital adjustment, $\phi_Z$ equal to zero and rebate the banking profit to households in a lump-sum fashion. Then we also shut down the sticky interest rate channel. It is obtained by setting $\phi_i$ and $\phi_l$ equal to zero in the no-BK model model. To obtain no-B model, we set $\alpha' = \alpha'' = 0$ and the elasticities of loan and deposit, $\varepsilon'$ and $\varepsilon''$ equal to infinity. no-B model is a single interest rate model with financial frictions but no banking sector. The steady state values of the two models differ as the effective lending rate and deposit rate faced by the agents are not the same. Since the steady-state under the two models is different, this plot is only instructive.
The Effects of a Tightening of Credit Conditions

Starting in the summer of 2007, financial markets all across the globe fell under considerable strain. The initial deterioration in the U.S. sub-prime mortgage market quickly spread across other financial markets. Banks, in particular, suffered losses from write-offs and increasing funding difficulties. A number of them were forced to recapitalize and improve their balance sheets. In addition financial intermediaries tightened credit standards for the approval of loans. Against this background, policymakers were particularly concerned with the impact that a restriction in the availability and cost of credit might have on the real economy. Our model is well suited to analyze the effects of a tightening in credit conditions on the real activity. We carry out this exercise by implementing a persistent contraction in bank capital $\zeta$.\footnote{Similar to Gerali et al. (2010) we model the credit condition tightening as a simple negative shock to the bank capital.} The shock is calibrated in a way such that it determines a fall of bank capital by 5 percent on impact. In the exercise, we assess the role of the adjustment costs on the bank capital/asset ratio by computing the impulse responses under different calibration of the parameter $\phi_z$. We consider as benchmark a value of 10, and then a higher one, corresponding to 15, and a lower one equal to 5. Figure 1.8 presents the impulse response of macro variables to a negative shock to bank capital $\zeta$.

By construction, the credit tightening brings about a fall in bank capital. In order to compensate for the loss in equity, banks increase the rate on deposits to attract them and increase their liability. At the same time, they increase the rates on loans to increase profits. This pushes up the costs of borrowing for entrepreneurs, reducing their net worth, which in turn decreases the demand for capital, leading to a decline in investment and output. Since banks try to re-build their capital, the spread increases.

Higher the cost of adjusting the bank capital ratio, the larger is the increase in the lending rates, resulting in larger decline in net worth, demand for capital, investment and output. Output contracts on impact only when the adjustment cost is sufficiently large. With high adjustment costs, spread between wholesale loan and wholesale deposit rates increase; bank profits increase and compensates for the fall in equity. The bank capital-loan ratio converges faster to its steady state. Response of consumption depends on the size of the adjustment cost. Gerali et al. (2010) have also found similar results.
Figure 1.8: Impulse Responses to a Negative Shock to Bank Capital
(Baseline model with different bank capital adjustment costs)

Note: Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. Low BK cost model has bank capital adjustment cost, $\phi_Z = 5$ while High BK cost model has bank capital adjustment cost, $\phi_Z = 15$. 
Unconventional Monetary Policies

Next we analyze the monetary transmission mechanism associated with non-monetary tools generally employed by the central banks in emerging markets. Policymakers resort to cash reserve requirements generally for two reasons – to control inflation by soaking up liquidity (or decreasing aggregate demand) and mitigate financial stability risks by retarding credit growth. Statutory liquidity requirements were used for similar reasons in the Philippines as well as possibly to create a captive source of financing and keep borrowing costs low for the government. While liquidity requirements are no longer used monetary policy purposes, the impact of shocks to the share of government securities held by banks could mimic the likely counterpart impact of sudden shifts in non-resident holdings of government securities. While analyzing the effect of these non-monetary policy tools, we assume that the central bank keeps the policy rate unchanged.

Shock to Cash Reserve Requirement

We present the impulse response of macroeconomic variables to a positive shock in CRR (increase in CRR by 50 bps) in Figure 1.9. The policy achieves its intended objective of reducing inflation. Since banks have less credit available to lend, they increase the lending rate. This results in higher borrowing costs for entrepreneurs, causing net worth to decline. Also a decline in inflation results in higher debt repayment which also reduces the net worth of the firms. It puts downward pressure on the demand for capital, resulting in the decline of investment and output. The financial accelerator mechanism results in further reduction in investment and output. Since banks are left with less credit to meet the loan requirements, they have to tap additional deposits and also use bank capital. Deposits go up. Since the bank’s profitability goes down they use their bank capital to meet the demand for loans, resulting in a worsening of their balance sheet. Lowered economic activity results in lower wage income and lower dividend income for the households. This reduces their consumption demand. Also as households shift to deposits, their current consumption demand is further reduced.

Shock to Statutory Liquidity Ratio

We present the impulse response of a positive shock to SLR (increase in SLR by 50 bps) or the share of government securities held by banks in Figure 1.10. Banks are forced to lend to the government at a lower than the lending rates and possibly below the market rate (since they only earn the t-bill rate). In order to maximize their profits, banks raise the lending rates. Higher lending rates and declining inflation leads to an increase in the borrowing costs for the firms. Thus even though the policy rate is unchanged, borrowing costs for the firms go up. This sets in the financial accelerator mechanism, leading to contraction in output, investment and consumption. Since in our model the government has a balanced budget, increased t-bill holdings in each period result in lowering of t-bill rates, which further reduces the profits of banks. This does not have to be case in an emerging market and t-bill rates could rise with budget deficits and/or non-resident sales of government securities to domestic banks but that would still be contractionary as foreign borrowing costs would rise as debt increases. Lowered economic activity results in lower wage income and lower
dividend income for the households. This reduces their consumption demand. Also as households shift to deposits, their current consumption demand is further reduced.

Figure 1.9: Impulse Responses to a Positive Shock to Cash Reserve Ratio (CRR)

Each variable’s response is expressed as the percentage deviation from its steady state level. Interest rates are shown as absolute deviation from steady state. We assume that the central bank does not change the policy rate while changing the reserve requirements i.e. $i_t = i_{t-1}$. 

Figure 1.10: Impulse Responses to a Positive Shock to Statutory Liquidity Ratio (SLR)

Each variable's response is expressed as the percentage deviation from its steady state level. Interest rates and spread are shown as absolute deviation from steady state. We assume that the central bank does not change the policy rate while changing the reserve requirements i.e. $i_t = i_{t-1}$.

We have examined monetary and productivity shocks to understand the role of the banking sector and financial frictions in the transmission of shocks and their effect on the real economy. Results are similar to those of Mandelman (2009) in terms of amplification of shocks when the interest rates are flexible. However, when rates are sticky, our results are comparable to Gerali et al (2010), where the presence of banking sector attenuates the shocks. A similar attenuator effect arises also in Andres and Arce (2009) and Aslam and Santoro (2008). Our model also suggests that using non-traditional monetary tools may result in larger volatility than using a traditional monetary tightening.
E. Conclusions

The global crisis has amply demonstrated that financial shocks can have a significant effect on the real economy. Macro-financial linkages have become the focus of attention in both academia and central banks. This crisis has also highlighted the need of introducing banking sector (credit supply channel) in a standard DSGE model with financial frictions (credit demand channel) to study and analyze shocks emanating in the credit markets.

The aim of this paper has been to develop a small open economy model with financial frictions and a banking sector to understand the role of financial intermediation in the transmission of shocks, and to analyze the effects of credit market shocks on the real economy. The model includes a financial accelerator mechanism similar to that proposed by Bernanke et al. (1999). Banks are modeled as monopolistically competitive optimizing units. They combine deposits with the bank capital (accumulated out of retained earnings) to make loans while meeting the capital-asset requirement. We have introduced cash reserve ratio (CRR) and statutory liquidity ratio (SLR) in the model to study the non-monetary policy tools used by central bank in emerging markets.

Our analysis suggests that the presence of financial frictions result in the amplification and persistence of shocks, while the presence of monopolistic sticky interest rate setting banking sector attenuates the effect of shocks. However, if interest rates are flexible, market power of banking system results in the amplification of shocks. Other results suggest that tightening of credit markets (a negative shock to bank capital) have substantive effects on the economy, and when the central bank resorts to using non-monetary tools and/or results in domestic banks holding a greater share of government securities, there is a larger contraction in output and consumption as compared to traditional monetary tightening (operating through nominal interest rate changes). The results are driven by the fact that we have two channels through which the financial sector interacts with the real economy. The banking sector affects the real economy through the credit supply channel. Presence of banks creates a wedge between the policy rate and rates which are relevant for the decision making of each agent in the economy, modifying the response of real variables. The financial accelerator mechanism works by altering the cost of borrowing faced by the firms.

The model developed in this paper can be used extensively to analyze several issues related to financial sector and financial stability. Since the model includes bank capital channel, our model is well suited to study the effects of bank recapitalization programs.

Our model with reserve requirements can be used to study the macro-economic consequences of using different policy tools and to rank them as well as to study the welfare costs of various financial frictions and financial under-development. It can also be extended to study the welfare costs of various rigidities in the financial markets. By estimating the parameters of the model using Bayesian techniques we can use it to study the optimality of monetary policy in the Philippines and emerging markets, in general. Also, it can then be used to assess the relative importance of shocks in explaining business cycle fluctuations in the Philippines.
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