

**Credit Multiplier Effects of Foreign Exchange Reserves  
under Monetary Sterilization and Capital Adequacy Constraints:  
A Preliminary Analysis and Evidence from China (2002-2008)\***

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# **Credit Multiplier Effects of Foreign Exchange Reserves under Monetary Sterilization and Capital Adequacy Constraints: A Preliminary Analysis and Evidence from China (2002-2008)**

## **I. Introduction**

The ongoing financial crisis has rekindled academic interest in the study of credit channel of monetary policy.<sup>1</sup> Bliss and Kaufman (2003) incorporates capital constraint into a banking model in addition to the required reserve constraint and finds that procyclical changes in bank assets and credit crunches contribute to economic instability during economic recessions. Kopecky and VanHoose (2004) further endogenizes capital constraint into a model with standard money multiplier and analyzes the interaction between monetary and bank regulatory policies. Wu (2006, 2009) analyze the monetary sterilization and the resulting partial loss of monetary autonomy in China with the surge of foreign exchange reserves. The present study intends to answer the following questions: What will be the determinants of the credit multiplier with respect to the foreign exchange inflow that is partially sterilized by the monetary authority? How does it compare with traditional money and credit multipliers? What is the key for maintaining China's relative monetary stability in the presence of the surge of foreign exchange reserves?

## **II. A Simple Model**

Consider a commercial bank system that has the balance sheet with four typical asset components: loans (L), securities (S), required bank reserves (RR),

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<sup>1</sup> For the representative works along this line, see Bernanke and Blinder (1988), Kashyap and Stein (1994), Kopecky and VanHoose (2003), among others.

and excess reserves (ER); and two liability components: transaction deposits (D), and bank capital (K). Here, the sum of loans and securities in the bank balance sheet represents the yuan amount of total credit (TC) extended by depository institutions. By the balance sheet property, we have

$$TC = D + K - RR - ER \quad (1)$$

Suppose that the bank system has the following parameters: capital-deposit ratio ( $\gamma$ ), capital-total credit ratio ( $k$ ), total credit-deposit ratio ( $t$ ), required reserve-deposit ratio ( $rr$ ), excess reserve-deposit ratio ( $er$ ), and currency-deposit ratio ( $c$ ), where currency refers to the currency in circulation. The capacity of banking system in extending credit is restricted by its holding of reserves as well as its possession of bank capital. Given that bank reserves are part of the monetary base (high-powered money), the monetary authority can influence credit creation through its influence on required bank reserves. Denote the monetary base by MB and currency by C, we have

$$MB = C + RR + ER \quad (2)$$

Rewriting (1) and (2) into the expressions involving pertinent ratio terms generates their respective forms below:

$$TC = (1 + \gamma - rr - er)D \quad (1)'$$

and

$$MB = (c + rr + er)D \quad (2)'$$

Note that based on the balance-sheet property of the monetary authority, MB can also be expressed as the sum of net foreign assets (NFA) and net domestic credit (NDC) that appear on the asset side of the authority's T-account, that is,  $MB=NFA+NDC$ . Hence, dividing (1)' by (2)' yields the formula that connects TC with the asset version of MB (Note:  $\gamma=kt$ ):

$$TC = \frac{1 + kt - rr - er}{rr + er + c} (NFA + NDC) \quad (3)$$

In fact, if the capital adequacy constraint and bank reserve constraint are effective, the relationship between capital-deposit ratio ( $\gamma$ ) and total credit-deposit ratio ( $t$ ) can be depicted in Figure 1 below. In Figure 1, the area above the both lines (i.e.,  $\gamma \geq kt$  and  $\gamma \geq t + \rho - 1$ ) represents a feasible region for  $\gamma$  and  $t$ , the area in which both capital-adequacy constraint and reserve constraint are satisfied. The size of the feasible region will shrink if the minimum capital-total credit ratio ( $\kappa$ ) increases so that the line  $\gamma=kt$  becomes steeper or the required reserve ratio ( $\rho$ ) increases so that the line  $\gamma=t+\rho-1$  shifts up.

Now, suppose that the monetary authority regularly conduct sterilized foreign exchange market interventions to offset some amount of increases in the monetary base that results from the inflow of foreign exchange reserves. Denote the sterilization coefficient by  $s$ . Using the difference form, we can derive a credit multiplier associated with the constraints of monetary sterilization and capital adequacy:

$$\Delta TC = \frac{(1 + kt - rr - er)(1 + s)}{rr + er + c} \Delta NFA \quad (4)$$

The composite coefficient in (4) is the credit multiplier with the presence of monetary sterilization and capital adequacy constraint as well as reserve constraint. The composite credit multiplier measures the sensitivity of the total bank credit to changes in net foreign assets held in the monetary authority's balance sheet.

Examining the composite credit multiplier allows us to conclude that inflow of foreign exchange reserves tends to lead to greater credit expansion from banking system if either the sterilization coefficient (measured by its absolute value) or the reserve-deposit ratio or the currency-deposit ratio gets smaller. The capital-deposit ratio, however, has a positive impact on the composite credit multiplier, as either more capital is being held for a given amount of total credit created or more total credit is being created for a given amount bank deposit.

The above analysis also applies to the derivation of a loan multiplier when (1) is modified into

$$L = D + K - RR - ER - P \tag{1}'$$

where P is bank portfolio investment. Following the similar procedure, we can derive the composite loan multiplier as the coefficient of the following:

$$\Delta L = \frac{(1 + kt - rr - er - p)(1 + s)}{rr + er + c} \Delta NFA \tag{4}'$$

where p is the portfolio investment-deposit ratio.

### III. Preliminary Evidence from China (2002-2008)

In this section, we use the monthly data of the balance sheets of Chinese monetary authority and China's banking system to examine the evidence for the credit multiplier effects of foreign exchange reserves. Specifically, in the presence of the central bank's monetary sterilization efforts and banks' capital adequacy constraint, how significant is the monetary sterilization in maintaining monetary stability and controlling credit expansion? What is the major channel through which the surge of foreign exchange reserves is sterilized? How have traditional credit and monetary multipliers played a role in the process?

Figure 2 depicts three series of monetary aggregates: net foreign assets (NFA), net domestic credit (NDC), and the monetary base (MB). The lasting robust inflow of foreign exchange reserves has consistently accounted for the increase in China's higher-powered money since 2002. Beginning from the third quarter of 2005 when China abandoned its dollar-peg policy, the level of NFA started to exceed the level of MB, which indicates the fact that the other component of the monetary base must have been contracting by China's monetary sterilization policy.

Given that this paper measures the existing objective monetary sterilization that is not cast in any pre-imposed optimization context, Figure 3 demonstrates two measures of China's monetary sterilization. Panel a shows the frequency distribution of the various values of sterilization coefficient (STERI, which is denoted as  $s$  in the previous section). Despite the fact that sterilization doesn't take place each and every month, the scenario of incomplete sterilization as well as the scenario of over-sterilization has dominated the sample period.<sup>2</sup> In addition, as seen from panel b, most partial sterilizations occur in the

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<sup>2</sup> Wu (2006, 2009) discussed the various cases of sterilization in China based on the sterilization coefficient.

sample period since 2002 when the sterilization coefficient takes a value of negative fraction.

Figure 4 compares the composite credit multipliers incorporating monetary sterilization with traditional credit and money multipliers. First, let's examine the composite credit multiplier (CCM) that measures the total credit multiplier (including the banking system's loans and portfolio investment impacted by the net foreign exchange reserve inflow in the presence of sterilization) and its counterpart, the regular credit multiplier or earning asset multiplier (EAM) connecting the monetary base with the banking system's earning assets, i.e., loans plus portfolio investment. The series of CCM exhibits its declining trend over the sample period whereas the series of EAM is relatively stationary. It is particularly noted that in the third quarter of 2005, the series of CCM crosses from above the series of EAM; that is, before the third quarter of 2005, CCM is above EAM but after then, CCM is below EAM. It suggests that as indicated earlier China's sterilization has become more significant since the third quarter of 2005 and significantly reduced the power of credit expansion, as shown by the difference of the two credit multipliers. When we apply the similar analysis to another pair of credit multipliers: the composite credit multiplier that measures the sensitivity of bank loans with respect to the net foreign exchange reserve inflow in the presence of sterilization (CCM2) versus the loan multiplier that gauges the responsiveness of bank loans to the monetary base as a whole, we have found the nearly same pattern. Overall, the traditional credit multipliers (EAM and LM) and money multipliers (M1M and M2M) are relatively stable or stationary over time, though the monetary base sees increasingly greater expansionary impacts on the following ascending sequence: M1, bank loans, bank earning assets, and M2.

To better gauge the determinants of credit expansion, a decomposition of the credit multiplier is necessary. Figure 5 plots four ratios of the traditional credit multiplier: the reserve-deposit ratio (R\_DPT), bank capital-deposit ratio (BC\_DPT), currency-deposit ratio (CUR\_P\_DPT), and portfolio investment-deposit ratio (PI\_DPT). Chinese banks stopped their “theoretical bankruptcy” in 2007 and started to build up the bank capital with the capital injections from the monetary authority since then; over the entire sample period, capital adequacy conditions have improved and exhibited an upward trend. In contrast, the reserve-deposit ratio and the currency-deposit ratio appear to be moving in tandem or relatively synchronized in terms of their local peaks and troughs, reflecting their close movement with business cycles and seasonality factors, even though the series of R\_DPT is more fluctuating and thus less stationary than the series of CUR\_P\_DPT and exhibits a moderate upward trending. As a determinant of the traditional loan multiplier, the series of PI\_DPT essentially moves around a mean value of 0.14, however.

Based on the analysis of Figure 5, it is not surprising to see the stationarity of two traditional measures of credit multipliers: EAM and LM, both of which are simply exhibiting their flat means (see Figure 4). Therefore, the monetary authority’s control of credit expansion essentially comes from its sterilization power, which depends on the issuance of People’s Bank of China’s (PBOC) sterilization bonds. The two panels of Figure 6 demonstrate the sterilization mechanism. In panel a, the amount of PBOC’s sterilization bonds (PB\_BOND) are increasing with the monetary base (MB), meaning that the PBOC has been engaged in a policy that intends to mop up the undesired excessive increase in the money supply brought about by the surge of foreign exchange reserves. The sale or issuance of sterilization bonds reduces bank reserves by increasing the PBOC’s nonmonetary liabilities, which explain the pattern of movements in the series of PB\_BOND and MB. As shown in panel b of the same figure,



whenever the amount of sterilization bonds rises, it is most likely to be associated with the decrease in the bank reserves, and *vice versa*.

#### IV. Concluding Remarks

This paper provides a simple framework in which the monetary authority's monetary sterilization and capital adequacy constraint influence the banking system's credit multipliers. Unlike traditional credit multipliers, the composite credit multiplier effectively explains the monetary authority's sterilization power by incorporating the sterilization coefficient. Based on the preliminary evidence from the aggregate Chinese banking system's balance sheet and the People's Bank of China's balance sheet, China's monetary stability has essentially hinged on the PBOC's sterilization measures in the face of the surge of foreign exchange inflows since 2002; as a result, the composite credit multiplier exhibits its robust declining trend despite the fact that other monetary policy measures (reserve requirement, capital adequacy requirement, and moral suasion) has kept the traditional credit multiplier rather stable in the sample period.

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Figure 1

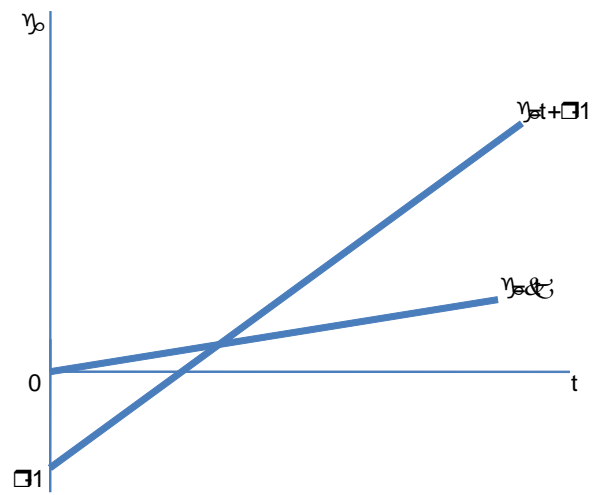


Figure 2

Monetary Base and Its Components

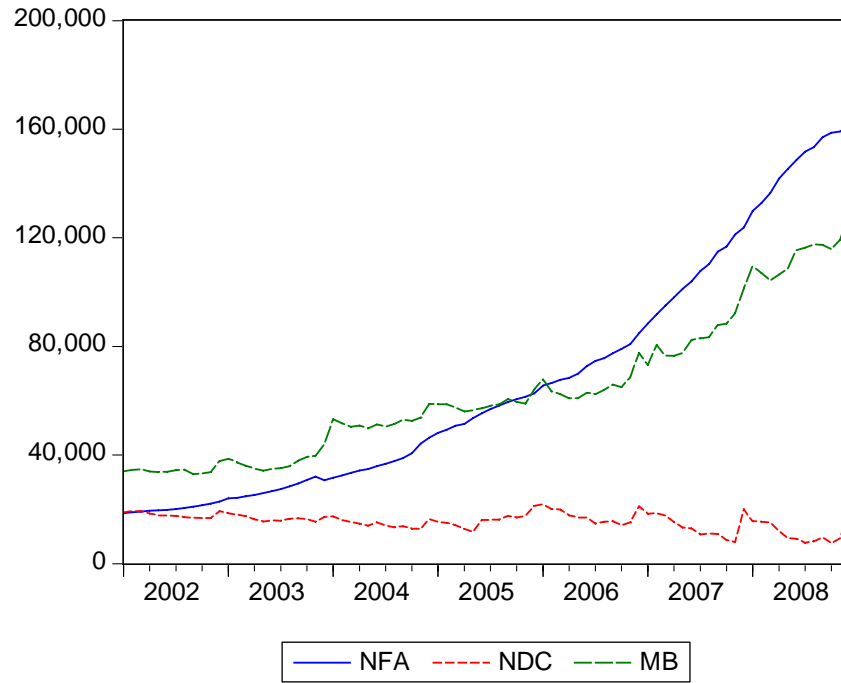
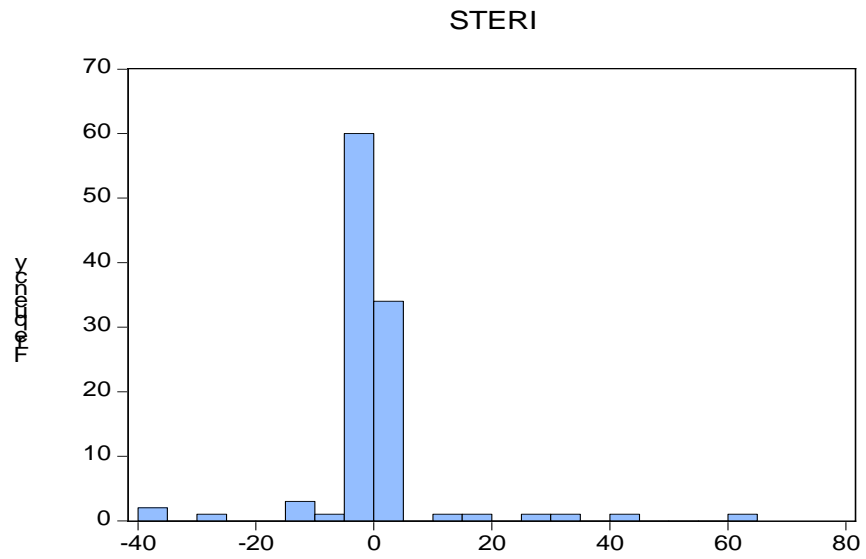


Figure 3

Panel a: Frequency



Panel b: Time-series

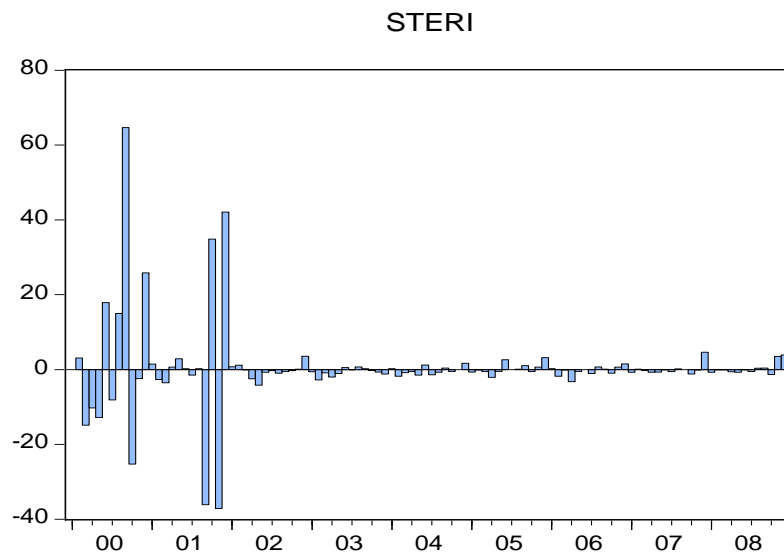


Figure 4

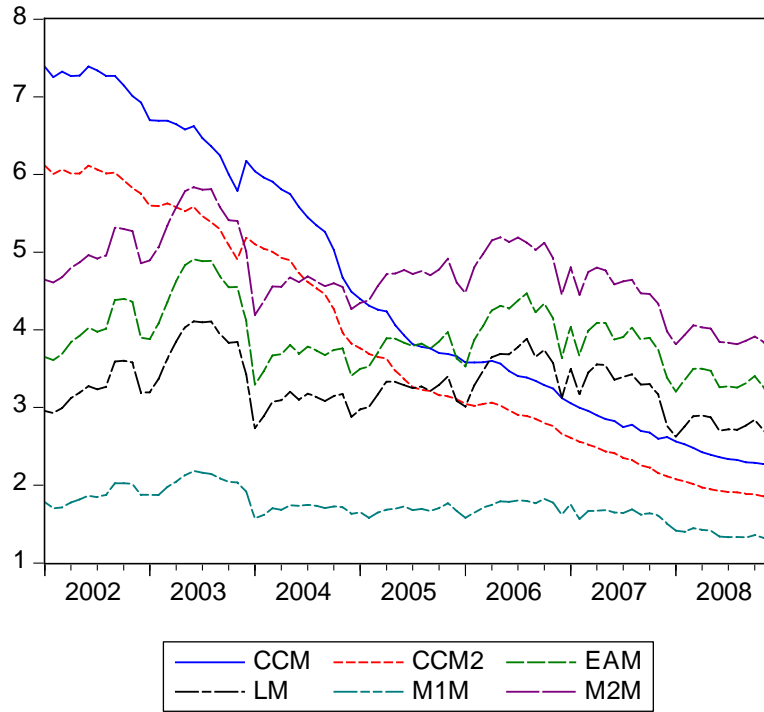


Figure 5

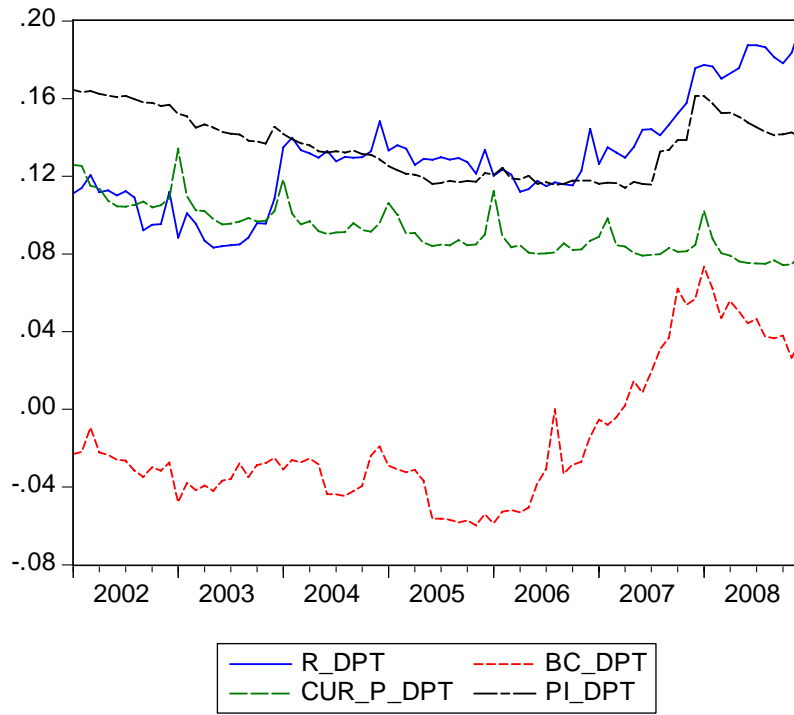
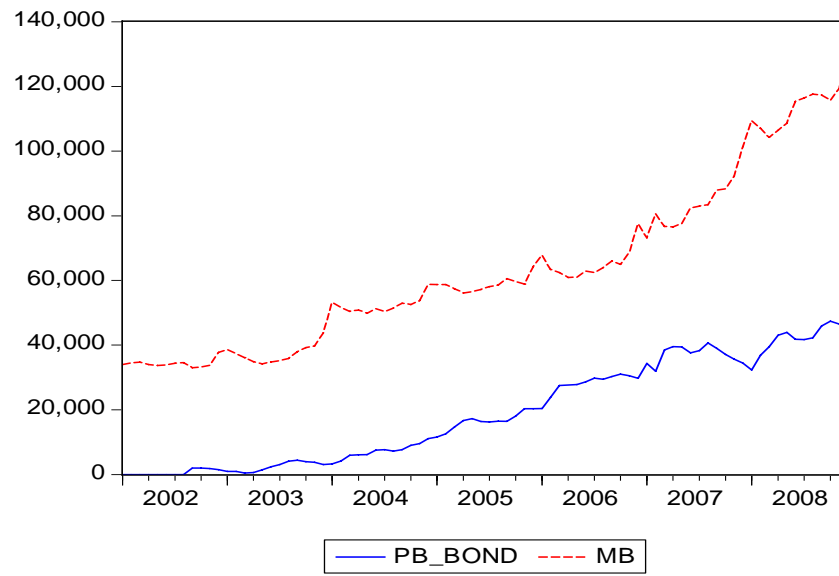


Figure 6

Panel a



Panel b

