China as a Reserve Sink:
The Evidence from Offset and Sterilization Coefficients

by

Alice Y. Ouyang [a] , Ramkishen S. Rajan [b] and Thomas D. Willett [c,*]

[a] *Department of Economics, Claremont Graduate University, CA 91711, USA*

[b] *School of Public Policy, George Mason University. VA 22201, USA*

[c] *Department of Economics, Claremont Graduate University and Claremont McKenna College.CA 91711, USA*

October 2006

---

* Corresponding author: Tel.: +1 909 621 8787; Fax: +1 909 621 8460; *Email address:* Thomas.Willett@cgu.edu (T. Willett)

Excellent research assistance by Nicola Vargill is gratefully acknowledged. This paper was completed while the second author visited the Hong Kong Institute for Monetary Research (HKIMR). The author gratefully acknowledges the hospitality and support offered by the HKIMR. The views expressed in this paper are those of the authors and do not necessarily reflect those of the HKIMR, its Council of Advisors, or the Board of Directors .Comments on earlier versions from Richard Burdekin, Leroy Laney, and Pierre Siklos are gratefully acknowledged as is financial support from the Freeman Foundation Program in Asian Political Economy at the Claremont Colleges.

China as a Reserve Sink:
The Evidence from Offset and Sterilization Coefficients

Abstract

China has been stockpiling international reserves at an extremely rapid pace since the late 1990s and has surpassed Japan to become the largest reserve holder in the world. This paper undertakes an empirical investigation to assess the extent of *de facto* sterilization and capital mobility using monthly data between mid 1999 and late 2005. We find that China has been able to successfully sterilize most of these reserve increases thus making it a reserve sink such as Germany was under the Bretton Wood system. Recursive estimation of offset coefficients, however, finds evidence of increasing mobile capital flows that may undercut China's ability to continue high levels of sterilization.

JEL classification: E51; E52; E58

Keywords: Balance of payments, China, Capital Mobility, Reserves, Sterilization

1. Introduction

China has become the world's largest foreign exchange reserve holder, having amassed over US$ 800 billion of international reserves by early 2006 (Figure 1).[1] The rapid accumulation of reserves has generated several controversies. One concern is whether this continuing balance of payments surplus signals the need for a substantial revaluation or appreciation of the Chinese Yuan (CNY) to protect China both from the inflationary consequences of the liquidity buildup and a misallocation of resources[2] as well as to help ease global economic imbalances. An alternative view, particularly associated with McKinnon (2003a,b, 2004), argues that a fixed exchange rate is an optimal policy for China and the larger Asian region both on the grounds of macroeconomic stability and rapid economic development. The global monetarist approach of McKinnon is based on the assumption of little or no sterilization of reserve accumulations, so that any payments imbalance is temporary. However, many other commentators have suggested that the Chinese government's concern with inflation has led the People's Bank of China (PBC) to heavily sterilize these reserve inflows.

Contrary to the wide spread concerns among many economists about the huge size of current global economic imbalance, Dooley et al. (2004) famously argued that mainstream economists have failed to recognize that we are now in a new informal version of the Bretton Woods system (BW2) and the global economy is therefore not in genuine disequilibrium. While there are clearly important analogies between the current international monetary system and Bretton Woods (BW1), the question is still open to

[1] China overtook Japan to become the world's largest reserve holder in February 2006. The other top reserve holders in the world at this time are also Asian – Taiwan, Korea, India, Singapore and Hong Kong – with each country holding over US$ 100 billion in reserves.

[2] Rodrik (2006) discusses the issue of opportunity costs of stockpiling reserves. The World Bank (2005) and Mohanty and Turner (2005) discuss the quasi fiscal costs of sterilization and capital losses on reserve assets arising from exchange rate fluctuations. We return to the issue of fiscal costs of sterilization specifically for China in the concluding section.

whether we are currently closer to the early or late days of BW1. In the later days of BW1 much attention was given to the concept of countries as *reserve sinks* into which reserves flowed. Instead of stimulating adjustments, as assumed in global monetarist models, the reserves effectively disappear from the system (down the sink) and hence contributed to continuing disequilibrium. Germany was seen as the prototype of the reserves sink during the BW1 days. Today China appears to be playing that role. Thus investigating how China has reacted to its reserve increases is of international as well as national importance.[3]

An intermediate view is that while China has sterilized most of its past reserve increases, continuing to do so is becoming increasingly difficult for China as its reserves continue to rise and capital controls become more porous (Prasad, 2005, Prasad and Wei, 2005, and Xie, 2006). One of the reasons why there is so much disagreement is because, as Goodfriend and Prasad (2006) have noted, "(t)he fraction of reserves sterilized by the central bank has varied over the last few years and it is not straightforward to assess exactly how much sterilization has taken place."

This paper estimates the degree of recent sterilization in China, as well as the degree of capital mobility as measured by offset coefficients, i.e. the fraction of an autonomous change in the domestic monetary base that is offset by international capital flows.[4] In one sense, the level of sterilization can be observed from the degree to which the central bank takes action to offset the effects of increases in international reserves on the domestic base or other monetary aggregates. However, this can offer a misleading picture of the effectiveness of sterilization since if the central bank wants the base to increase anyway, then it would decide not to neutralize the reserve increases; this would not imply

[3] See Willett (1980) for references to this literature.

[4] After this paper was initiated, two other studies on sterilization in China by Burdekin and Siklos (2005) and He et al. (2005) became available. While using a different methodology, they reach broadly similar conclusions. These studies are considered in FN 41.

that it had lost control of the domestic monetary process. China's large balance of payments surplus in 2003 was accompanied by rapid domestic money and credit expansion which is consistent with an inability to effectively sterilize. It appears, however, that the primary cause of the rapid expansion of money and credit was Chinese government's concern with maintaining rapid economic growth, not the inability of the PBC to control the domestic monetary base.[5] Thus, the PBC did not try to fully neutralize the domestic monetary effects of the reserve increases under government direction.

To investigate the central bank's ability to control domestic monetary aggregates, it is necessary to estimate the extent to which international flows undercut its control. This in turn requires the estimation of the counterfactual of the desired rate of monetary growth, i.e. estimation of the central bank's monetary reaction function. There is no one correct theoretical specification for central bank reaction function, but the literature has developed a standard set of variables to be considered within this function. This allows us, at least in principle, to breakdown the interrelationship between international reserve changes and the monetary base into those relating to autonomous changes in the monetary base (the offset coefficient) and those relating to autonomous changes in international reserve flows (the sterilization coefficient). We also make use of recursive estimation to investigate changes in offset coefficients and sterilization over time. While we find no evidence of the inability of the government to sterilize a high proportion of reserve accumulations, we do find substantial increases over time in our estimates of the offset coefficients, suggesting that sterilization is becoming increasingly difficult.

The next section briefly explores the evolution of the balance of payments flows in China since the late 1990s, focusing on the magnitude and sources of reserve buildup as

[5] Lardy (2005) argues that the money expansion in 2003 was the government's mistaken overreaction to the potential adverse effect of severe acute respiratory syndrome (SARS) on economic growth.

well as the reserve buildup's monetary consequences. It also briefly discusses the sterilization policy measures used in China (*de jure* sterilization). Section 3 offers a summary of the main empirical methodologies commonly used to estimate the *de facto* extent of sterilization. As will be discussed, the estimation procedure used in this paper is based on a set of simultaneous equations to estimate both the "sterilization coefficient" (i.e. how much domestic money creation responds to a change in international reserves) and the "offset coefficient" (i.e. how much balance of payments changes in response to a change in domestic money creation). Since the foreign exchange and the domestic monetary markets are interrelated, ignoring such interrelationships can lead to biased results. Section 4 discusses the data and definitions of variables to be used in the empirics. This section also discusses the empirical results of the sterilization and offset coefficients based on monthly data for the period from mid 1999 to late 2005. The final section concludes with a brief discussion of the macroeconomic policy implications and tradeoffs facing China in the future.

2. Reserve Growth and Sterilization Policy Measures in China since 1990

2.1 Evolution of China's Balance of Payments[6]

Our empirical analysis begins with 1999 since relevant monthly data are not available for earlier years. China's large reserve accumulation began in earnest in 2001 (Figure 2). China has experienced large and growing surpluses on both the capital and current accounts since 2001, while even the errors and omissions balance (a broad proxy for capital flight by residents) turned positive. Thus, reserves increased markedly during this period. An interesting dynamic appears to have taken hold in China (as well as in many other Asian economies) during this period. Large reserves are viewed as a sign that the domestic currency will eventually appreciate. They also tend to be taken as an indication of "strong fundamentals," hence leading to an upgrading of the country's credit ratings. This expectation of future capital gains and lower risk perceptions motivated large-scale capital inflows and added to the country's stock of reserves as central banks have mopped up excess US dollars.

From Figure 3, it is apparent that the swelling of China's capital account surplus since 2003 was largely because of a surge in portfolio capital flows as well as "other investments" (i.e. short-term debt flows), most likely a reflection of mounting market expectations of an impending revaluation of the Chinese currency (i.e. speculation on the CNY as a one-way trade). As noted by Prasad and Wei (2005), "much of the recent increase in the pace of reserve accumulation is potentially related to 'hot money' rather than a rising trade surplus or capital flows such as FDI that are viewed as being driven by

[6] The evolution of capital inflows to China throughout the 1990s is explored in more detail by Prasad and Wei (2005) and Prasad (2005). Also see He et al. (2005), and Ma and McCauley (2005).

fundamentals" (p.8).[7] Goldstein and Lardy (2006) concludes, however, that even with hot money flows excluded, China faces a substantial payments disequilibrium.

The Chinese government finally loosened its strict US dollar peg and allowed for a small revaluation from 8.28 to 8.11 CNY per US dollar in July 21, 2005 and simultaneously announced that the currency would be pegged to a basket of currencies.[8] Interestingly, China has since experienced a sharp increase in its trade surplus relative to the capital account despite expectations of continued upward pressure on the CNY[9] (i.e. one logically would have expected to see an intensification of speculative inflows). On the one hand, the decline in the capital account surplus was partly policy-induced. The government has been promoting outward investments by Chinese corporates and domestic institutional investors and has loosened a number of restrictions on capital outflows to ease some appreciation pressures from huge reserves accumulation, while simultaneously tightening some restrictions on capital inflows such as imposing a quota in July 2004 on offshore borrowing by foreign banks operating in China. On the other hand, the sharp increase in the country's current account balance is somewhat harder to rationalize.[10] It has been suggested by some observers that the current account surplus has been partly driven

[7] Three caveats should be noted. First of all, part of the change in reserves is also because of a valuation effect as a portion of reserves that was invested in non-US dollars (gold, euros, etc) has changed in US dollar terms (while most central banks including the PBC do not disclose the composition of assets in which reserves are being invested, it is generally suggested that a large part has been invested into dollar-denominated assets like Treasury securities). Prasad and Wei (2005) offer some "guess-timates" on the possible valuation effects. Secondly, there was a one-off fall in reserves in China in 2004. This was because since 2003 the government transferred US$ 60 billion to three state-owned banks, Bank of China (US$ 22.5 billion), China Construction Bank (US$ 22.5 billion), and Industrial and Commercial Bank of China (US$ 15 billion) to aid in their recapitalization (see Ma, 2004 for details). And lastly, while China has not yet become fully convertible on the capital account, a large number of so-called "qualified foreign investment institutions" or QFIIs received approval by the China Securities Regulatory Commission to increase their investments to China which in turn has fuelled large-scale portfolio capital inflows (see Hu, 2004 for details).

[8] The CNY has been on a very gradual appreciating path since July 2005. See Ogawa and Sakane (2005) for a discussion of the currency weights in China's basket.

[9] This expectation is apparent from examining the Non Deliverable Forward (NDF) market on the CNY.

[10] Prasad and Wei (2005) and Liu and Otani (2005) detail the steps taken to deregulate China's capital account transactions.

by over-invoicing of exports and under-invoicing of imports. As noted by one market commentator:

> The massive flip-over between the financial account and trade account... in 2005…raises the possibility that capital flow for...(CNY)..speculation masqueraded as a trade surplus last year due to improving capital account control. This is important in understanding the nature of China's BoP surplus. 2005 BoP data suggest that capital account flows accounted for one-third of the BoP surplus, while 2004 data suggest that this was three-quarters. If 2004 data are more accurate, the appreciating pressure appears to be mainly a speculative phenomenon (Xie, 2006).[11]

2.2 Sterilization Policy Measures in China

What are the monetary consequences of this huge reserve buildup in China? Figure 4 shows that, since December 2002, domestic high-powered money creation proxied by the growth in broadly defined net domestic assets (NDA)[12] has remained rather low if not negative. This helped moderate the increase in the domestic monetary base (MB) and overall money supply (*M2*) (Figure 5), suggesting that the PBC was actively neutralizing the impact of the reserves buildup using various policies and instruments. Two conventional sterilization policies frequently used by the PBC are open market operations (OMOs) and raising reserve requirements (He et al., 2005). In early 1998, the PBC used treasury bonds or securities as the sterilization tools. But since September 2002, the PBC has replaced all outstanding securities with central bank bills (CBCs) for use in the OMOs. Figure 6 reveals the sharp growth in PBC issuances in the last five years. In addition, the

[11] Also see Ma and McCauley (2005) who state that a large part of the overall current account surplus in China (40 percent) was also due to net income transfers. They further note that the Chinese government required banks to report "unusually large" (US$ 10000) remittance inflows and related dollar sales.

[12] Broadly defined net domestic assets (NDAs) equals monetary base (MB) minus net foreign assets (NFAs).

PBC has begun to issue short-term repurchases ranging from 7 days to 182 days to do sterilization in these three years.[13]

Since 1998, the PBC has required state banks to hold greater levels of bank reserves to reduce the money multiplier. The PBC has also begun increasing the benchmark interest rate to curb liquidity growth. In addition, the PBC has undertaken a series of market-based interest rate reforms, such as broadening the floating band of financial institution lending rates at the beginning of 2004.[14] These monetary policy actions have been accompanied by administrative measures including window guidance to halt the nongovernment-approved construction loans and cool down specific sectors. Other measures, such as moral suasion and risk warnings, have also been conveyed to commercial banks to try to maintain "reasonable" credit growth and optimize resource allocation. The government also introduced measures to curb the rapid escalation of property prices in May 2006 (Ma, 2006).

3. Estimating the Extent of Sterilization: Methodological and Empirical Issues

3.1 Empirical Methodologies Commonly Used

Most current studies which estimate the extent of sterilization can be classified into three groups. The first group assumes that capital flows are exogenously determined and typically estimate sterilization coefficients by running simple *OLS* on the monetary reaction function such as the one below:

$$\Delta NDA_t = c_0 + c_1 \Delta NFA_t + X'\beta + u_t \qquad (1)$$

[13] He et al. (2005) outline some of the improvements/changes made by the PBC in its conduct of OMOs in 2003-2004.

[14] In addition, commercial banks have been allowed a greater degree of autonomy in deciding medium and long-term RMB loan interest rates.

where ΔNDA_t and ΔNFA_t represent the change in net domestic assets (a proxy for domestic money creation) and net foreign assets (a proxy for international reserves), respectively, and X represents other explanatory variables that might influence a monetary authority's reaction. The coefficient of $c_1 = -1$ represents full monetary sterilization, while $c_1 = 0$ implies no sterilization. In some instances (such as Burdekin and Siklos, 2005), ΔMB_t or $\Delta M2_t$ is used instead of ΔNDA_t. If this is the case then $c_1 = 0$ represents full sterilization since a rise of international reserves does not significantly impact the monetary base (or broad money).

The second group uses a VAR model to estimate the lagged effects of NDAs and NFAs. The standard form of a VAR model is as follows:

$$\Delta NDA_t = \alpha_{10} + \sum_{i=1}^{k} \alpha_{1i} \Delta NDA_{t-i} + \sum_{i=1}^{k} \beta_{1i} \Delta NFA_{t-i} + e_{1t} \quad (2a)$$

$$\Delta NFA_t = \alpha_{20} + \sum_{i=1}^{k} \alpha_{2i} \Delta NFA_{t-i} + \sum_{i=1}^{k} \beta_{2i} \Delta NDA_{t-i} + e_{2t} \quad (2b)$$

Some papers within this group include additional variables in the model such as domestic interest rate, price level, or exchange rate (for instance, see Cavoli and Rajan, 2006, Christensen, 2004, He et al., 2005 and Moreno 1996).[15] The advantage of a VAR approach is that it allows one to trace out the time path of the various shocks on the variables contained in the VAR system (i.e. the impulse response function). If a shock from foreign

[15] Takagi and Esaka (1999) argue that it is inappropriate to use this approach to measure the effectiveness of sterilization given the variety policy instruments used in sterilization in addition to OMOs. Consequently, the authors use the change of $\Delta M1_t$ (or $\Delta M2_t$) rather than ΔNDA_t; full sterilization is said to exist if an unexpected increase in foreign assets is not associated with a corresponding increase in overall money supply.

assets (say an unexpected increase in foreign assets) is associated with an offsetting decrease in domestic money creation, it can be concluded that the sterilization is significant. An important limitation of the VAR approach is that it tends to treat all variables as symmetrically endogenous. As equations 2a and 2b show, a standard form of the VAR model only yields the estimated values of lagged NDAs and NFAs due to the issue of identification. Consequently, the model cannot estimate the contemporary effect of variables without restrictions.

The third group of studies -- including this paper -- estimates the contemporaneous relationship between NDAs and NFAs using a set of simultaneous equations. Although the studies in the first group ignore the simultaneous bias by assuming capital flows are exogenously determined,[16] it is important to note that domestic monetary conditions are affected by changes in international capital flows and foreign reserves. Concurrently, international capital flows respond to a change in domestic monetary conditions (e.g. higher domestic interest rates would, *ceteris paribus*, lead to greater capital inflows).[17] Some early studies, such as Argy and Korui (1974) and Herring and Marston (1977) , have suggested using a simultaneous system to overcome the problem of simultaneity.

The typical model specification for a set of simultaneous equations is:

$$\Delta NFA_t = \alpha_{10} + \alpha_{11}\Delta NDA_t + X_1'\beta_1 + u_{1t} \qquad (3a)$$

$$\Delta NDA_t = \alpha_{20} + \alpha_{21}\Delta NFA_t + X_2'\beta_2 + u_{2t} \qquad (3b)$$

[16] See Kwack (2001).
[17] Indeed, this is the basic dilemma involved in sterilization (Calvo, 1991), a point we return to in Section 4.

where X_1 and X_2 are the vectors of controls in the balance of payment function and monetary reaction function, respectively. Eqs. (3a) and (3b) are the balance of payments and the monetary reaction functions, respectively. The former estimates the "offset coefficient". The expected value of the offset coefficient is bound by 0 in the event of no capital mobility and -1 in the event of perfect capital mobility.[18] The latter measures the sterilization coefficient. The expected value of the sterilization coefficient is -1 if reserve buildup is perfectly sterilized and 0 if the central bank does not sterilize at all. In general, the greater the degree of capital mobility the less effective is monetary sterilization; a small offset coefficient and a large sterilization coefficient generally imply that the central bank has a fairly high degree of monetary policy independence to neutralize the impact of capital flows effectively on a sustained basis.

3.2 Specification of the Simultaneous Equation Model

One concern with all the above approaches is the lack of explicit micro foundations for inclusion or exclusion of control variables. There is of course a large literature on the determinants of monetary reaction function, but to our knowledge Brissimis-Gibson-Tsakalotos (BGT) (2002) is the only instance in which the simultaneous equations used to estimate the NFAs and NDAs are explicitly derived from a theoretical framework (minimization of a simple loss function of the monetary authority subject to a number of constraints that reflect the workings of the economy). Ouyang et al. (2006) modify the BGT framework in a number of ways and apply it to several Asian economies. However, the modified framework cannot be applied directly to China which maintained a fixed peg to the US dollar until July 2005. Nevertheless, the vector of controls we use in the

[18] Obstfeld (1982) argues that an estimated offset coefficient may be seriously biased if we ignore the problem of endogenity between domestic and foreign components of the monetary base.

simultaneous model is informed by the modified BGT model and from existing empirical work in this area (for instance, see Celasun et al., 1999, Fry, 1993, Kim, 1995, Nyatepe and Coo, 1995, Sarjito, 1996 and Rooskareni 1998). We specify a set of simultaneous equations as follows:

$$\begin{aligned}\Delta NFA_t^* = \alpha_0 &+ \sum_{i=0}^{n} \alpha_{1i} \Delta NDA_{t-i}^* + \sum_{i=0}^{n} \alpha_{2i} \Delta mm_{t-i} + \sum_{i=1}^{n} \alpha_{3i} \Delta p_{t-i} + \sum_{i=1}^{n} \alpha_{4i} y_{c,t-i} \\ &+ \sum_{i=0}^{n} \alpha_{5i} \Delta REER_{t-i} + \sum_{i=0}^{n} \alpha_{6i} \Delta (r_{t-i}^* + E_t e_{t+1-i}) + \varepsilon_t \end{aligned} \tag{4}$$

$$\begin{aligned}\Delta NDA_t^* = \beta_0 &+ \sum_{i=0}^{n} \beta_{1i} \Delta NFA_{t-i}^* + \sum_{i=0}^{n} \beta_{2i} \Delta mm_{t-i} + \sum_{i=1}^{n} \beta_{3i} \Delta p_{t-i} + \sum_{i=1}^{n} \beta_{4i} y_{c,t-i} \\ &+ \sum_{i=0}^{n} \beta_{5i} \Delta G_{t-i} + \sum_{i=0}^{n} \beta_{6i} \Delta (r_{t-i}^* + E_t e_{t+1-i}) + v_t \end{aligned} \tag{5}$$

where

ΔNFA_t^* = The change in the adjusted net foreign assets scaled by the GDP (adjustments to be discussed in Section 4.4).

ΔNDA_t^* = The change in the adjusted net domestic asset scaled by the GDP (adjustments to be discussed in Section 4.4).

Δmm_t = The change in money multiplier for M2.[19]

Δp_t = The change in consumer price index.

$y_{c,t}$ = Cyclical income.[20]

ΔG_t = The change in government expenditure scaled by the GDP.

$\Delta REER_t$ = The change in the real effective exchange rate (REER).

$\Delta(r_t^* + E_t e_{t+1})$ = The change in foreign interest rate plus the expected nominal exchange rate (CNY/US$).[21]

e_t = Nominal exchange rate (CNY per US$).

---

[19] We also tried the $M1$ money multiplier but the results were not substantially changed.

[20] Gerlach and Peng (2006) discuss various ways of measuring the output gap in a fast-growing and developing country, like China, that is undergoing significant structural changes. They find that various output gap measures, including estimates derived from the HP-filter rule, are quite highly correlated.

[21] The exchange rate is in logarithms. As discussed in Section 4, we use three different assumptions for expected nominal exchange rate: perfect foresight, static expectations, and forward rates based on the NDF market for CNY.

As can be seen from equations (4) and (5), the balance of payments function (Eq. 4) consists of five control variables encompassing both "push" and "pull" factors as well as monetary policy responses, i.e. factors that motivate capital flows into specific recipient countries. We expect these variables to influence the balance of payments function in the following ways: First, a rise in the *M2* money multiplier increases broad money and pushes the interest rate down, hence reducing capital inflows. In addition, a rising multiplier might be capturing an overall tightening credit policy, including a more restrictive policy towards capital inflows.[22] Second, higher inflation perpetuates concerns about exchange rate depreciation, interest rate hikes and capital losses thereof, hence causing a reduction of capital inflows.[23] Third, higher lagged real output could worsen the current account (due to the income effect), reducing foreign reserve accumulation. However, this variable is a double-edged sword in the sense that a domestic boom could perpetuate capital inflows directly (i.e. pull factor). Fourth, foreign reserves will be decumulated due to a decrease in the current account if the REER is positive (price effect).[24] The use of one period lags in the REER, cyclical output as well as inflation also reduces the possible endogeneity problems. For instance, it could be argued that greater capital inflows and reserve buildup can lead to a real exchange rate appreciation and a domestic economic boom. Fifth, a fall in either the change in foreign interest rates or in the expected exchange rate depreciation could lead to increased capital inflows from the country.[25]

---

[22] It is plausible that a change in capital flows causes a concomitant change in the money multiplier (for instance, see Rajan, 2006). More generally, one might think about specifying a separate equation endogenizing the money multiplier (Jha and Rath, 2001).

[23] Additionally, higher inflation could engender greater uncertainty, leading to reduced capital flows.

[24] Ideally one needs to use a measure of real exchange rate misalignment rather than its change. Short of estimating the "equilibrium" REER we tried the deviation of the REER from its trend, but the results did not improve. See Section 4.3 for other robustness checks undertaken.

[25] Two caveats should be noted. First of all, we use only foreign interest rates rather than interest rate differentials as the domestic interest rates are already captured in the ΔNDA_t term. Secondly, there are

The monetary policy function (Eq. 5) also consists of five control variables that are considered important factors influencing monetary policy actions. The monetary authority generally implements a contractionary monetary policy in response to a rise in inflation (for obvious reasons), an increase in the money multiplier (to curb overall money supply growth), or an expected exchange rate depreciation (either for its own sake or because of pass-through concerns). The expected coefficient for each of these variables should therefore be negative. In addition, the monetary authority tends to adopt a countercyclical monetary policy to contract domestic money creation when there is a rise in real GDP growth rate above the trend (i.e. a domestic economic boom) or a more expansionary fiscal deficit, implying a negative expected coefficient again.[26] We are least certain about the last variable as it is subject to a number of caveats. During an economic downturn there could be simultaneous use of expansionary monetary and fiscal policies and vice versa during an upturn in economic activity. It is also important to consider the context of expansionary fiscal policy. If done in the event of an economic downturn, the impact may not be similar as when done when output is at or above trend.

4. Empirics

4.1 Data and Definitions

Our estimations are based on monthly observations over the sample period from 1999: m6 to 2005: m9. All the data are from the *IMF-IFS* or *TEJ Great China* database[27]

---

two other potentially important push factors causing increased capital flows into China, viz. a fall in risk premium and rise in foreign wealth. The other push factor, viz. industrial country growth, is likely highly correlated with domestic country cyclical growth which is already included in the equation. Dasgupta and Ratha (2000) and Montiel and Reinhart (2000) discuss the determinants of capital flows into developing countries.

[26] More precisely, one would want to use a measure of broader fiscal stance, viz. full employment primary fiscal balance.

[27] See http://www.tei.com.tw/greatdb/greatDB.html .

(except the three month CNY non-deliverable forward rate (NDF) which is from *Bloomberg*). Table 1 summarizes the definitions and sources of the various data used in the estimating equations. The relevant variables, such as the change in the "adjusted" ΔNFA_t^*, ΔNDA_t^* and ΔG_t fiscal deficit are scaled by GDP.[28] To check for stationarity we applied the standard ADF unit root test to each of the variables and found all variables to be stationary at the 10 percent significant levels with the exception of the exchange rate adjusted foreign interest rates (see Table 2).[29,30]

We used the Hodrick-Prescott (HP) method to measure the trend of real output. We assume that economic agents have three different ways of forming their expectations about the exchange rate. If economic agents have perfect foresight then the difference between the actual nominal exchange rate at the next period and the current nominal exchange rate is the appropriate proxy for the expected exchange rate depreciation for the next period. If agents have static expectations then the exchange rate change at the current period is used as the proxy. Finally, the three month CNY NDF rate is also used as a proxy for the expected exchange rate for the next period. Table 3 provides the summary statistics of the various variables used in the model.

4.2 Adjustments to the NDAs and NFAs

A typical balance sheet of the monetary authority is as follows:

Balance Sheet of Monetary Authority

[28] Three caveats should be noted. One, the manner of "adjustment" of the NFAs for revaluation effects is discussed in Section 4.2. Two, for the monthly data, the variables are scaled by "monthly GDP", which is measured by distributing quarterly GDP into corresponding three months weighted by the industrial production ratio. Three, we tried the regressions without scaling by GDP (since we are using first differences), but the coefficient on some variables, like the money multiplier, turned out to be far too large to make any economic sense.

[29] The ADF results were confirmed by the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test.

[30] Siklos (2000) pointed out a similar problem with the Hungarian-German interest rate differential and has argued that interest rates should not be difference stationary.

Assets	Liabilities and Equity
Foreign Assets (FA)	Currency in Circulation and Deposits (MB)
Domestic Assets (DA)	Foreign Liabilities (FL)
Other Assets (OA)	Domestic Liabilities (DL)
	Other Liabilities (OL)
	Equity (K)

Note: The format is taken from the *International Financial Statistics* (*IFS*) report.

Since both of the changes of NDA and NFA are based on the monetary authority's balance sheet, care must be taken in accounting for non-policy related changes in the variables such as the revaluation effects due to gold value and exchange rate fluctuations.[31] In order to exclude monetary gold from the foreign assets we use the product of foreign reserves denominated in US dollars and exchange rates (domestic currency/US$) to proxy foreign assets. The net foreign assets without the revaluation effect are as follows:

$$NFA_t = (R_t \times e_t) - FL_t \qquad (6)$$

where R_t is the foreign reserves denominated in US$ and e_t is the exchange rate against US$.

We use $(R \times e)$ rather than the actual FA in the PBC balance sheet as there are some differences between the two in the case of China, particularly in early 2002 when the latter declined sharply for an unknown reason. The problem with using $(R \times e)$ is that reserve values could change because of currency fluctuations. However, these valuation effects will not change the domestic currency value of the money base and we therefore need to exclude these effects from the book value of NFA before estimation. Ideally if we

[31] Other factors include interest earnings earned from foreign reserves accumulation. Given the low interest rates in China as well as the fact that the majority of its capital inflows relate to the private financial account, we ignore these factors.

had the currency composition of reserves we could adjust for the valuation changes. Given that such data is not available, the best we can do is assume that all reserves are held in US$ and adjust the reserves for changes in the CNY/US$ bilateral rate. However we also tried different currency composition of reserves holdings as do Prasad and Wei (2005). Results are fairly robust and discussed in Section 4.3.

Since the revaluation effect is the change of NFAs due to exchange rate fluctuation, it can be measured as follows. In general, the monetary authority recognizes the end-year revaluation of foreign currency liabilities and assets in the Profit and Loss account of the income statement. Since the end-year income statement balance will be included in the equity (K) account of the balance sheet, the change of net foreign assets due to the revaluation effect can be offset by the change of equity so that the domestic monetary base will be the same. In other words, if NFAs rises because of an increase in e_t, then $M\bar{B} = NFA \uparrow + NDA + NOA - K \uparrow$.

$$\text{Revaluation effect} = NFA_{t-1}\left(\frac{e_t}{e_{t-1}} - 1\right) \tag{7}$$

Therefore, the revised change of net foreign assets $= \Delta NFA_t^* = NFA_t - NFA_{t-1}\left(\frac{e_t}{e_{t-1}}\right)$. The adjusted variable excludes the price or valuation effect, which as noted, should have no direct impact on liquidity.

The adjusted NFA_t^* is derived as a residual component:

$$\Delta NDA_t^* = \Delta MB_t - \Delta NFA_t^*.$$

This effectively implies that $\Delta NDA_t^* = \Delta NDA_t + \Delta NOA_t - \Delta K_t + NFA_{t-1}(\frac{e_t}{e_{t-1}} - 1)$.

ΔNFA_t^* and ΔNDA_t^* will be used as the dependent variables in eqs. (4) and (5) respectively.

4.3 Empirical Results

We use two-stage least squares (2SLS) to estimate the simultaneous equations 4 and 5. We apply autocorrelation and heteroskedasticity tests to the residuals from the estimated equations [32] Newey-West heteroskedasticity and autocorrelation consistent (HAC) covariance estimates are used if there is a problem.[33] Table 4 summarizes the results of the estimating equations applying two-stage least squares on monthly data. We have three sets of estimations depending on whether we assume perfect foresight, static expectations, or forward-looking expectations. Forward-looking expectations are captured using the three-month forward rate (the one-month forward rate unfortunately being unavailable).

The estimated offset coefficients are around 0.63 to 0.70 and are statistically significant, indicating a substantial degree of capital mobility despite China's capital controls. The estimated sterilization coefficients are also highly statistically significantly different from zero, averaging in the range 0.92 to 0.97[34], suggesting that the PBC has heavily sterilized its reserve accumulations in the last six years. The money multiplier is statistically and economically significant across all the estimations with the correct sign.

[32] The serial correlation Lagrange multiplier (LM) test is used to check for the autocorrelation, while White's heteroskedasticity test is used to test the heteroskedasticity in the residuals.

[33] Newey and West (1987) have derived a consistent covariance matrix estimator in the presence of both heteroskedasticity and autocorrelation. Since we use the Newey-West HAC estimates we do not need to include lagged dependent terms as done by Brissimis, Gibson and Tsakalotos (2002) and others.

[34] The 95 percent confidence interval for the estimated sterilization coefficients is between 0.6 and 1.2.

Cyclical output is statistically significant and positive in the case of the balance of payments function, which suggests that the income effect leading to a worsening of the current account may be outweighed by a direct impact that positive cyclical income has on attracting capital inflows. The positive coefficient in the monetary reaction function is harder to fathom and is statistically insignificant. With one exception (that being the balance of payments function using the forward rate) the exchange rate adjusted foreign interest rate coefficients have the correct sign though they are also statistically insignificant. In the case of the balance of payments function, the lagged REER has the correct sign. In the case of the monetary reaction function, government expenditure is statistically significant with the correct sign. The lagged inflation term is positive in both periods across most regressions but statistically insignificant. Overall, the lack of either statistical or economic significance of the inflation coefficient in most if not all the regressions (pooled and country-specific) may be due to the fact that while the dependent variables are fairly volatile, the inflation series is quite stable (also see Brissimis, Gibson and Tsakalotos, 2002).

Following Siklos (2000) we also applied the recursive estimation on monthly data to estimate the dynamic change of offset and sterilization coefficients (see Figures 7a - 7c).[35] The recursive offset coefficient remained fairly stable between early 2003 and mid 2004 at 0.2 before rising sharply from thereafter to an average of about 0.6 by late 2005, indicating that *de facto* capital mobility increased quite substantially during this period. With regard to the recursive sterilization coefficients, the degree of sterilization during 2003 fluctuated from a low 0.5 to almost full sterilization by the end of the year. From early 2004 onward, however, sterilization has remained relatively stable at around 0.9. A

[35] Forward recursive estimation is applied. The first estimate is derived by using the sample from 1999: M6 to 2002: M12 and then adding one more observation each time to re-estimate the offset and sterilization coefficients.

closer examination suggests that there may have been a slight increase in sterilization in 2005 compared to 2004.

4.3 Robustness Checks

We undertook a number of robustness checks, but for sake of parsimony the estimated equations are not included in the paper.[36] Among the more important checks are the following. First, we tried various currency compositions of reserves, With the assumption of 90 percent US$ assets and 10 percent Euro assets, the estimated offset coefficients vary from 0.64 to 0.73 (depending on different ways of forming expected exchange rate depreciation), while the estimated sterilization coefficients vary from 0.9 to 0.93. With the assumption of 70 percent US$ assets, 20 percent Euro assets and 10 percent Japanese Yen assets, the estimated offset coefficients vary from 0.65 to 0.75, while the estimated sterilization coefficients vary from 0.88 to 0.9. Overall the empirical results are robust across different scenarios and assumptions.[37] We therefore maintained the assumption of 100 percent US$ assets for simplicity.

We replaced the lagged cyclical income and lagged REER with the trade balance (a done by as done by Brissimis, Gibson and Tsakalotos, 2002 and others). Second, we replaced the change in REER with deviation of REER from trend (as ideally one needs to use a measure of real exchange rate misalignment rather than change). Three, since theory has not offered guidance on lag structures, we tried up to two lags of all independent variables including adding the lagged dependent variables. In all of the cases the results were largely unchanged.[38] A Chow test for a structural break in late 2002 found that there

[36] They are available from the authors on request.
[37] Across various currency compositions of reserves considered, the 95 percent confidence interval for the estimated sterilization coefficients is between 0.54 and 1.19.
[38] Detailed regression results available from authors on request.

is a significant increase in estimated offset coefficients as expectations of Chinese Yuan appreciation first begins to be evident in the non-deliverable forward rate data.

5. Concluding Remarks

Our empirical results suggest that China's effective degree of capital mobility has risen substantially in recent years with offset coefficients rising from around 0.1 to 0.2 in 2003 to above 0.6 for the most recent data.[39] This is consistent with the judgments of a number of economists that China's capital controls have been becoming increasingly less binding.[40] To date, however, this increased effective capital mobility has not undermined the PBC's ability to effectively sterilize its huge reserve accumulation. We estimate that the PBC has typically sterilized around 90 percent of the reserve inflows, which is similar to those obtained by Burdekin and Siklos (2005) and He et al. (2005). While Burdekin and Siklos (2005) suggest the PBC has over-sterilized the foreign reserves, they find the PBC has not done so sufficiently to prevent M2 (broader money supply) from increasing, He et al. (2005) find that the PBC has fully sterilized the capital inflows, and most of the responses finish in a month.[41] This in turn explains how China has been able to maintain relatively low rates of money growth and inflation (Figure 8) despite the surge of capital inflows. Our recursive estimations match recent historical episodes, such as the substantial increase in sterilization at the beginning of 2004 as the PBC succeeded in slowing money growth after the acceleration in 2003.

[39] This conclusion is consistent with Liu and Otani (2005) and Ma and McCauley (2005), both of which undertake a battery of tests on various interest parity conditions.
[40] See for example Lardy (2005) and Prasad and Wei (2005).
[41] In related work, Burdekin and Siklos (2005) regress the change of base money on the change of foreign reserves for the period of 1990:q1 to 2002:q4 and find that one unit increases in the change of foreign reserves will lead to decreases of 0.1 to 0.2 units in the change of base money (based on OLS and GMM). However, they also find that one unit increases in the change of foreign reserves has significantly increased M2 growth by 0.11 units. Using VAR analysis, He et al. (2005) find that sterilization intensity increased somewhat in 2003:m1-2004:m12 compared to 1998:m1-2002:m12. They also find that one unit increases in NFAs will lead to a decline of around one unit in NDAs.

Our estimates of high sterilization over the period of China's recent huge buildup in reserves support the view that China has operated as a reserve sink, much as Germany and Japan did during the later stages of the Bretton Wood system. While Dooley et al. (2004) have suggested the current global economic imbalances are much less worrisome than most economists have suggested, the chaotic end of the Bretton Woods exchange rate regime in the early 1970s is but one of many examples that large prolonged international payments imbalances seldom lead to happy endings.

Finally, the high level of sterilization we found is not consistent with the strong form of the monetary approach and raises questions about arguments that China's pegged exchange rate has been an important source of discipline over domestic inflation (see, McKinnon, 2003a, 2003b, and 2004). Indeed, in recent years with the absence of sterilization, China's peg would have been a source of substantial inflationary pressure. Going forward, the Chinese authorities would do well to continue to relax the management of the exchange rate, in addition to taking further steps towards deregulation of capital outflows in a judicious manner. Less management of the exchange rate in turn should provide the PBC greater opportunities to use interest rate policy to manage domestic liquidity conditions and pressures.

References

Argy, V. and P.J.K. Kouri, 1974. Sterilization Policies and the Volatility of International Reserves," in R.Z. Aliber (eds.), National Monetary Policies and the International Financial System, Chicago: University of Chicago.

Brissimis, S., H. Gibson, and E. Tsakalotos, 2002. A Unifying Framework for Analyzing Offsetting Capital Flows and Sterilization: Germany and the ERM, International Journal of Finance and Economics, 7, pp.63-78.

Burdekin R. C. K. and P. L. Siklos, 2005. What has Driven Chinese Monetary Policy Since 1990? Investigating the People's Bank of China Policy Rule, mimeo (June)

Calvo, G., 1991. The Perils of Sterilization, IMF Staff Papers, 38, pp.921-936.

Cavoli, T. and R.S. Rajan, 2006. The Capital Inflows Problem in Selected Asian Economies in the 1990s Revisited: The Role of Monetary Sterilization, Asian Economic Journal, forthcoming.

Celasun, O., C. Denizer and D. He, 1999. Capital Flows, Macroeconomic Management, and the Financial System: Turkey, 1989-97, Policy Research Working Paper No.2141, The World Bank.

Christensen, J., 2004. Capital Inflows, Sterilization, and Commercial Bank Speculation: The Case of the Czech Republic in the Mid-1990s, Working Paper No.04/218, IMF.

Dasgupta, D. and D. Ratha, 2000. What Factors Appear to Drive Private Capital Flows to Developing Countries? And How Does Official Lending Respond?, Policy Research Working Paper 2392, The World Bank.

Dooley, M., D. Folkerts-Landau, and P. Garber, 2004. The Revised Bretton Woods System, International Journal of Finance and Economics, v9, pp.307-313.

Fry, M.J., 1993. Foreign Debt Accumulation: Financial and Fiscal Effects and Monetary Policy Reactions in Developing Countries, Journal of International Money and Finance, 12, pp.347-367.

Gerlach, S. and W. Peng, 2006. Output Gaps and Inflation in Mainland China, Working Papers No.194, BIS.

Goldstein, M. and N.R. Lardy, 2006. China's Exchange Rate Policy Dilemma, American Economic Review, No. 96, pp. 422-26.

Goodfriend, M. and E. Prasad, 2006. A Framework for Independent Monetary Policy in China,, Working Paper No.06/111, IMF.

He, D., C. Chu, C. Shu and A. Wong, 2005. Monetary Management in Mainland China in the Face of Large Capital Inflows, Research Memorandum 07/2005, Hong Kong Monetary Authority (HKMA), April.

Herring, R. J. and R. C. Marston, 1977. National Monetary Policies and International Financial Market, Amsterdam.

Hu, F., 2004. Capital Flows, Overheating, and Nominal Exchange Rate Regime in China, mimeo, Goldman Sachs.

Jha, R. and D.P. Rath, 2001. On the Endogeneity of the Money Multiplier in India, Working Paper Series No.2001-01, Australia National University.

Kim, G., 1995. Exchange Rate Constraints and Money Control in Korea, Working Paper No. 1995-011A, Federal Reserve Bank of San Francisco.

Kwack, S.Y., 2001. An Empirical Assessment of Monetary Policy Responses to Capital Inflows in Asia before the Financial Crisis, International Economic Journal, 15, pp.95-113.

Lardy, N.R., 2005. Exchange Rate and Monetary policy in China, Cato Journal, V.25, No.1 pp. 41-47

Liu, G.L. and I. Otani, 2005. Capital Controls and Interest Parity: Evidences from China, 1999-2004, mimeo (March).

Ma, G., 2006. Who Pays China's Restructuring Bill, Working Paper No.2006-04, CEPII.

Ma, G. and R.N. McCauley, 2005. Are China' Capital Controls Still Binding, paper presented at conference on Globalisation of Financial Services in China: Implications for Capital Flows, Supervision and Monetary Policy, Beijing, March 19.

Ma, T., 2006. China: Good Policy Moves – More Needed, More Coming, DBS Group Research, May 26.

McKinnon, R. and G. Schnabl, 2003a. Synchronised Business Cycles in East Asia and Fluctuations in the Yen/Dollar Exchange Rate, The World Economy, 26, pp.1067-1088.

McKinnon, R. and G. Schnabl, 2003b. China: A Stabilizing or Deflationary Inflation in East Asia? The Problem of Conflicted Virtue, Working Paper No.23, Hong Kong Institute for Monetary Research.

McKinnon, R. and G. Schnabl, 2004. The Return to Soft Dollar Pegging in East Asia: Mitigating Conflicted Virtue, International Finance, 7, pp.169-201.

Mohanty, M.S. and P. Turner, 2005. Intervention: What are the Domestic Consequences?, in Foreign Exchange Market Intervention in Emerging Markets: Motives, Techniques and Implications, BIS Papers No.24, pp.56-81.

Montiel, P. and C. Reinhart, 2000. The Dynamics of Capital Movements to Emerging Economies during the 1990s, in S. Griffith-Jones and M. Montes (eds.), Short-term Capital Movements and Balance of Payments Crises, Oxford: Oxford University Press.

Moreno, R., 1996. Intervention, Sterilization, and Monetary Control in Korea and Taiwan, FRBSF Economic Review, Federal Reserve Bank of San Francisco, 3, pp.23-33.

Newey, W. K. and K. D. West, 1987. Hypothesis Testing with Efficient Method of Moments Estimation, International Economic Review, 28, pp.777-787.

Nyatepe-Coo, A. A., 1995. Resource Shocks, Real Exchange Rate Appreciation and the Independence of Monetary Policy in Developing Oil-Exporting Countries, International Economic Journal, 9, pp. 91-107

Obstfeld, M., 1982. Can We Sterilize? Theory and Evidence, American Economic Review, 72, pp.45-50.

Ogawa, E. and M. Sakane, 2005. The Chinese Yuan after the Chinese Exchange Rate System Reform, mimeo, September.

Ouyang. Y. A., R.S. Rajan, and T.D. Willett (2006). From Bust to Boom in Emerging Asia: Monetary Management in the Face of Capital Inflow Surges. Mimeo (September)

Prasad, E., 2005. Next Steps for China, Finance and Development, 42, September.

Prasad, E. and S.J. Wei, 2005. Understanding the Structure of Cross-border Capital Flows: The Case of China,, mimeo, IMF, December.

Rajan, R.S., 2006. Financial Crisis, Capital Outflows and Policy Responses: Simple Analytics and Examples from East Asia, forthcoming in Journal of Economic Education.

Rodrik, D., 2006. The Social Cost of Foreign Exchange Reserves, International Economic Journal. Forthcoming.

Rooskareni, N., 1998. The Effects of Monetary Policy in Indonesia, unpublished PhD Dissertation, The Claremont Graduate University.

Sarjito, I., 1996. The Short-Run Independence of Monetary Policy in Indonesia: Estimation of the Offset Coefficient and the Monetary Authority's Reaction Function, unpublished Ph.D. Dissertation, The Claremont Graduate School.

Siklos, P., 2000. Capital Flows in a Transitional Economy and the Sterilization Dilemma: The Hungarian Experience, 1992-97, Journal of Policy Reform, 3, pp.413-438.

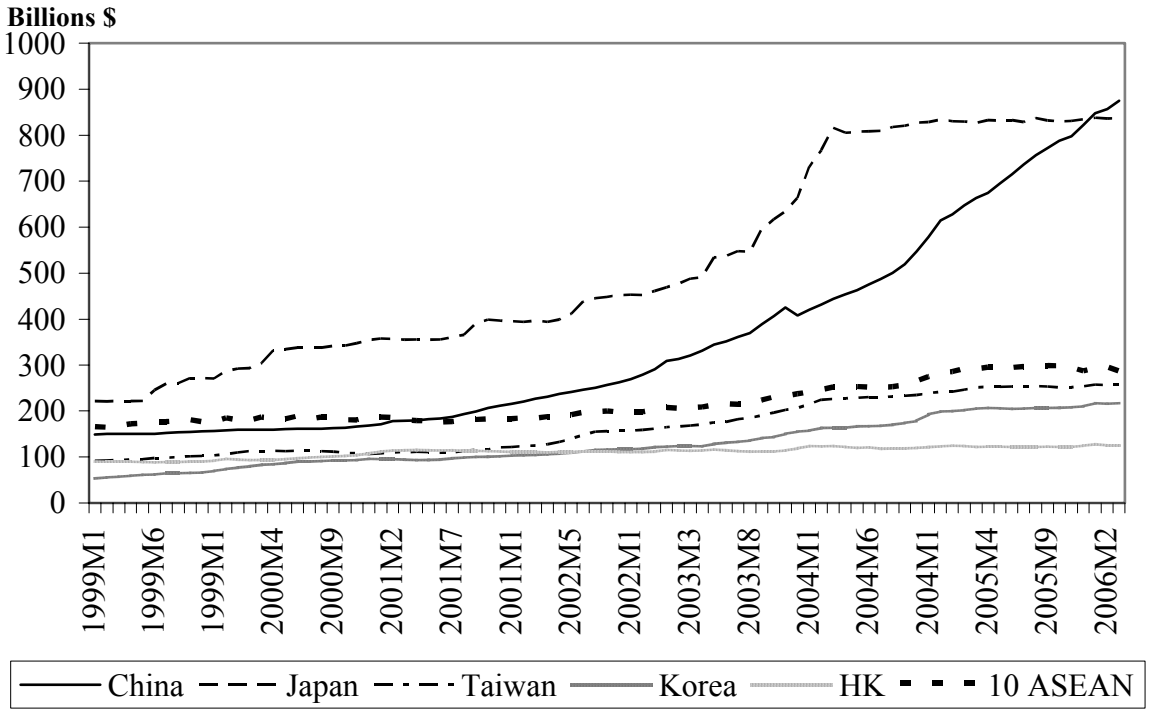
Takagi, S. and T. Esaka, 1999. Sterilization and the Capital Inflow Problem in East Asia, Discussion Paper No.86, Economic Planning Agency, Tokyo, Japan,

Willett, D. T. 1980. International Liquidity Issues, Washington, D.C., American Enterprise Institute for Public Policy Research.

World Bank, 2005. Global Development Finance 2005, New York: Oxford University Press.

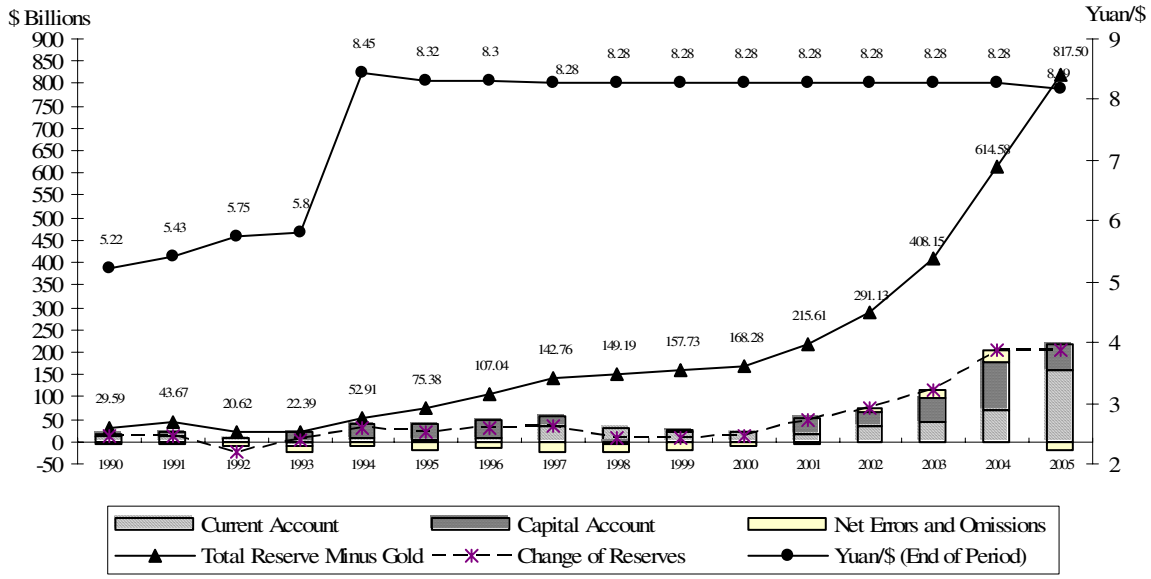
Xie, A., 2006. Asia Pacific: Hot Money Leaving?, Morgan Stanley Global Ecvonomic Forum, May 25.

Figure 1: Reserve Growth in China and Japan and East Asia (Billions of US$), 1999:M1-2006:M3



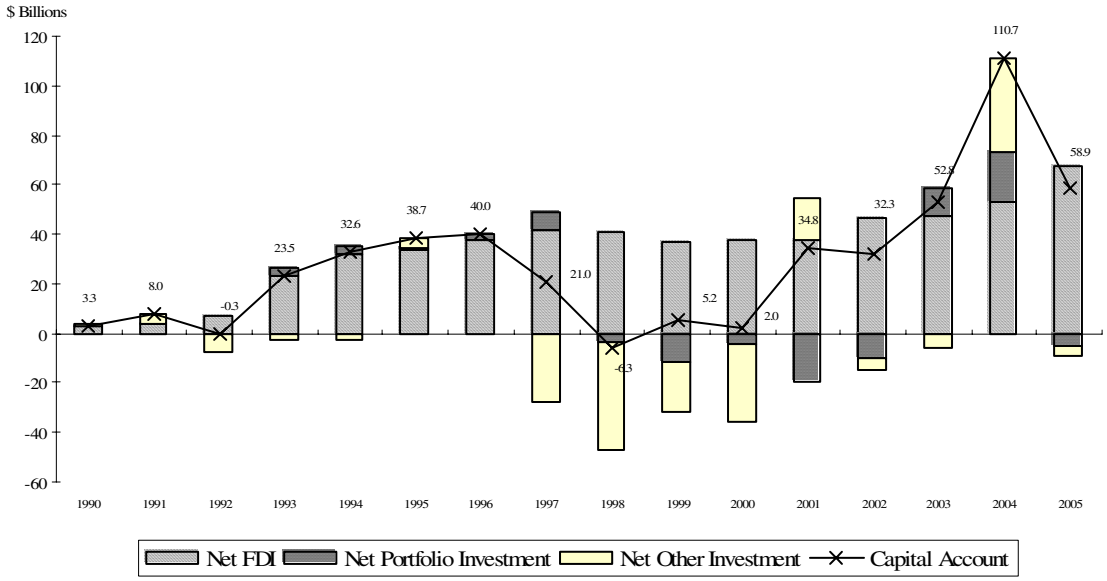
Source: All the data are from International Financial Statistics (IFS), expect Taiwan. The data for Taiwan is from AREMOS Economic Statistical Databanks, which published by Taiwan Economic Data Center (TEDC).

Figure 2: Trends in China's Balance of Payments Transactions (Billions of US$), 1990 - 2005



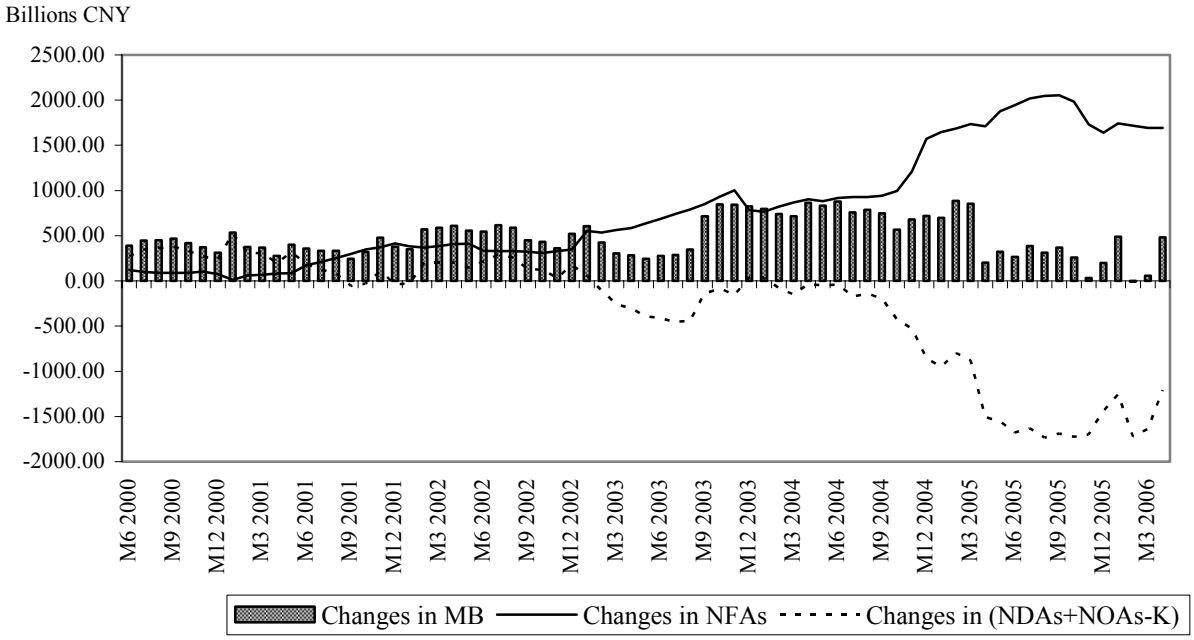
Source: IFS, the State Administration of Foreign Exchange (SAFE)'s website and Taiwan Economic Journal (TEJ) Great China Database.

Figure 3: Capital Account Components (Billions of US$), 1990 - 2005



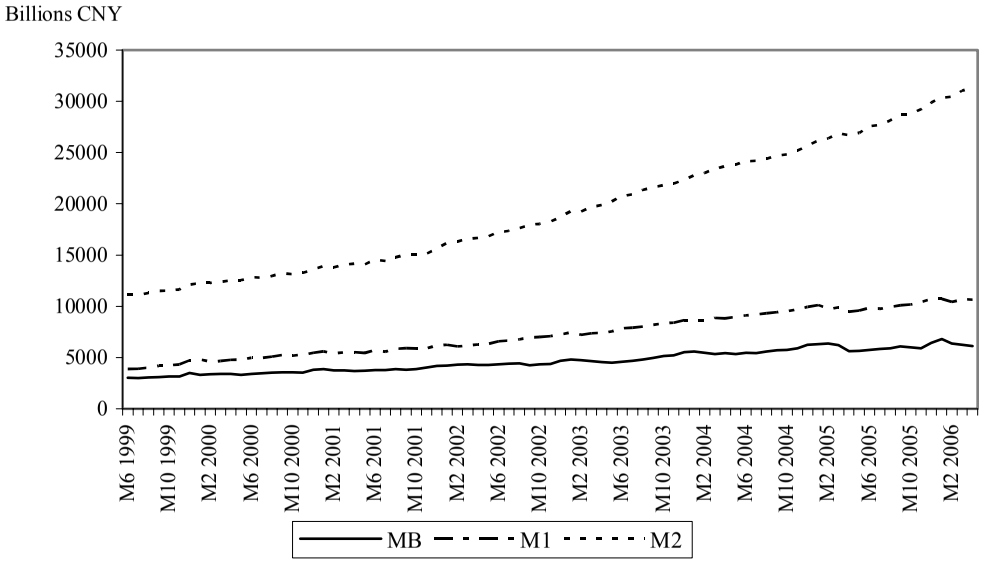
Source: IFS and the SAFE's website

Figure 4: Monthly Annual Change in NFAs, NDAs, and Reserve Money in China, 2000: M6 – 2006: M4



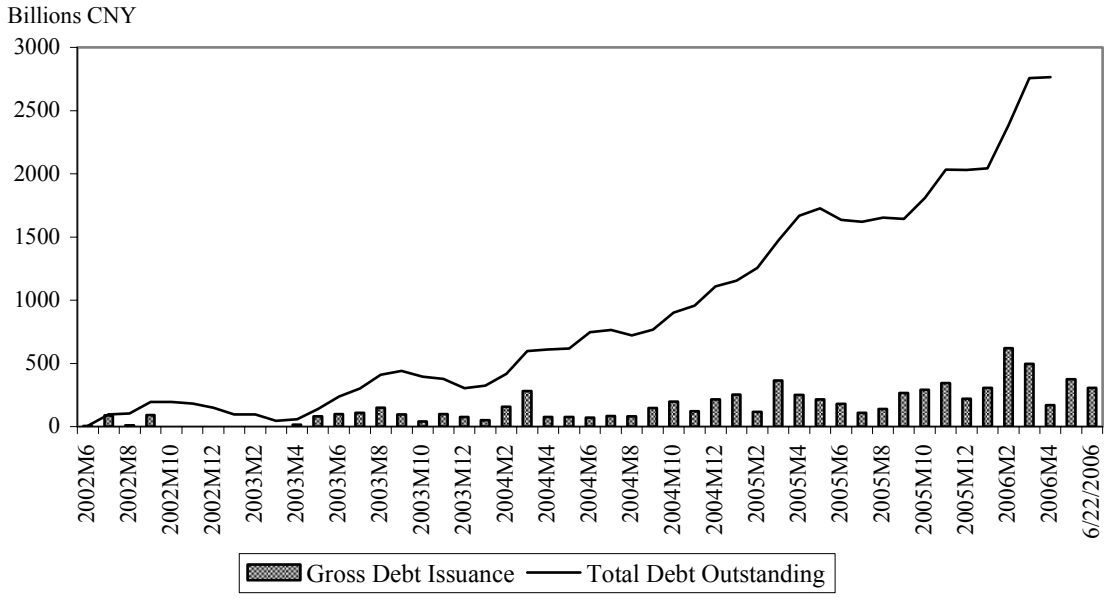
Source: IFS and the PBC's website

Figure 5: Reserve Money, M1, and M2 in China, 1999: M6 – 2006: M4



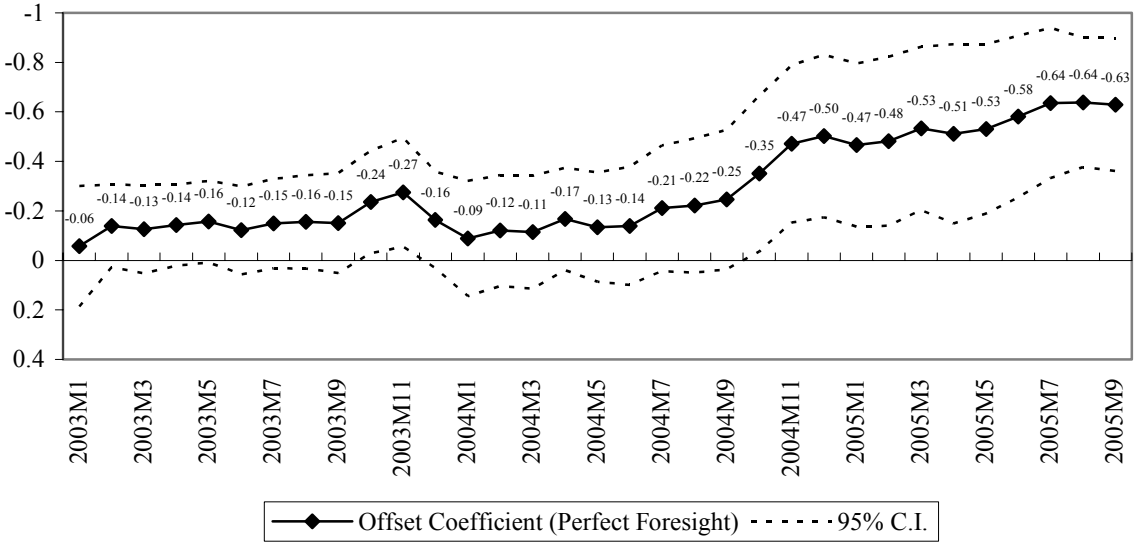
Source: IFS

Figure 6: Issuance of Central Bank Bills and Total PBC Debt Outstanding, 2002: M6 – 2006: M6



Source: PBC's website.

Figure 7a: Recursive Estimated Offset and Sterilization Coefficients, 2003:M1-2005:M9, (Perfect Foresight)



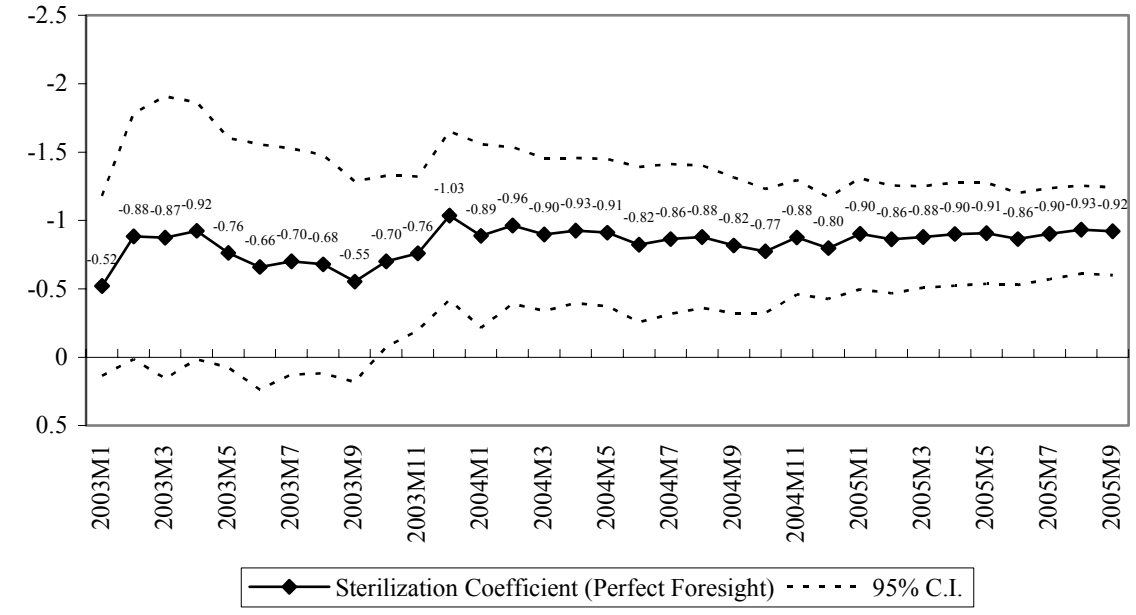
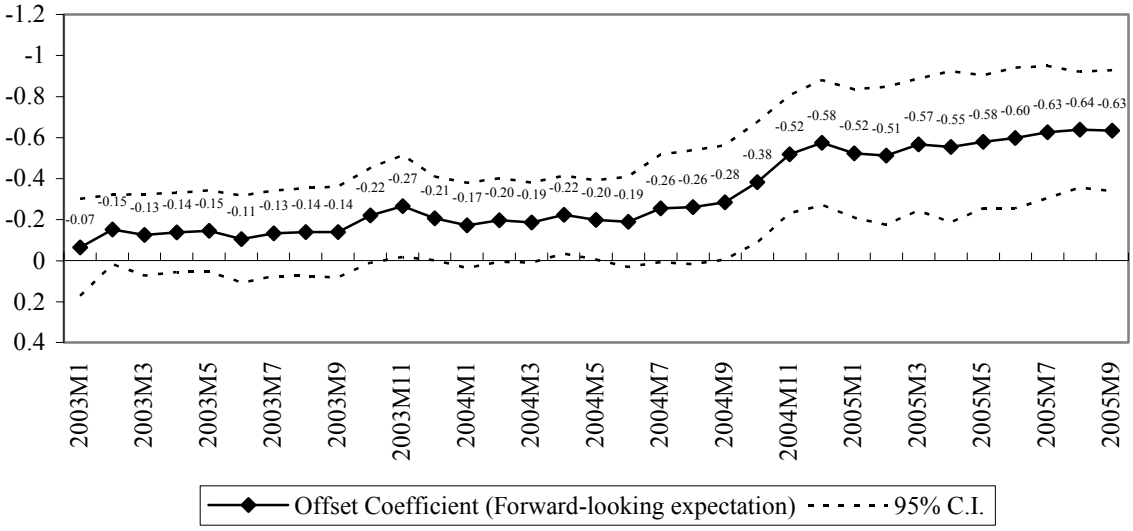


Figure 7b: Recursive Estimated Offset and Sterilization Coefficients, 2003:M1-2005:M9, (Forward-looking expectations)



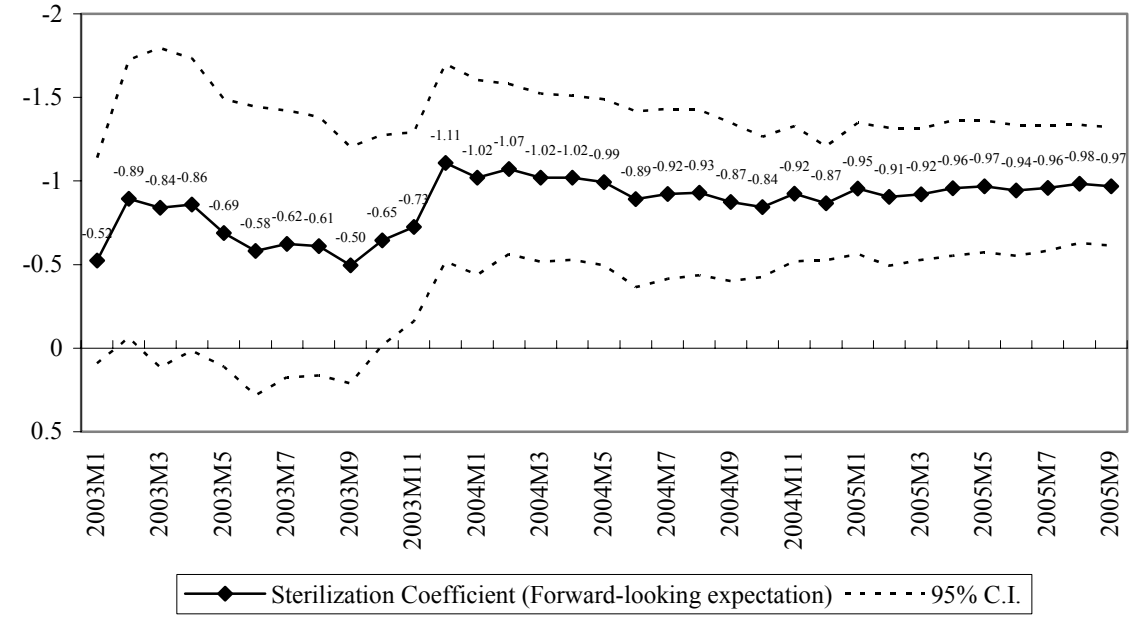
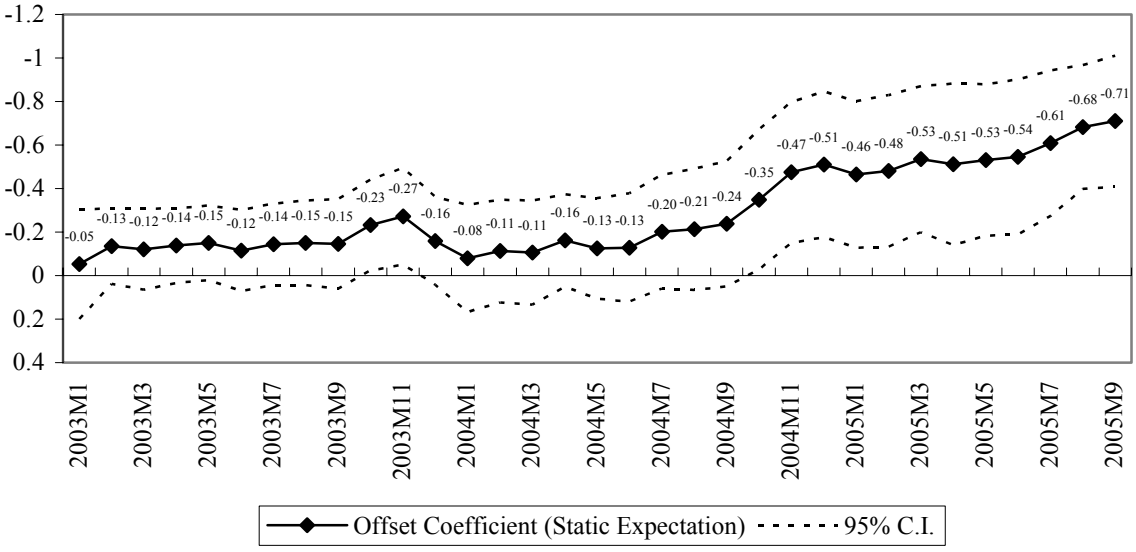


Figure 7c: Recursive Estimated Offset and Sterilization Coefficients, 2003:M1-2005:M9, (Static Expectations)



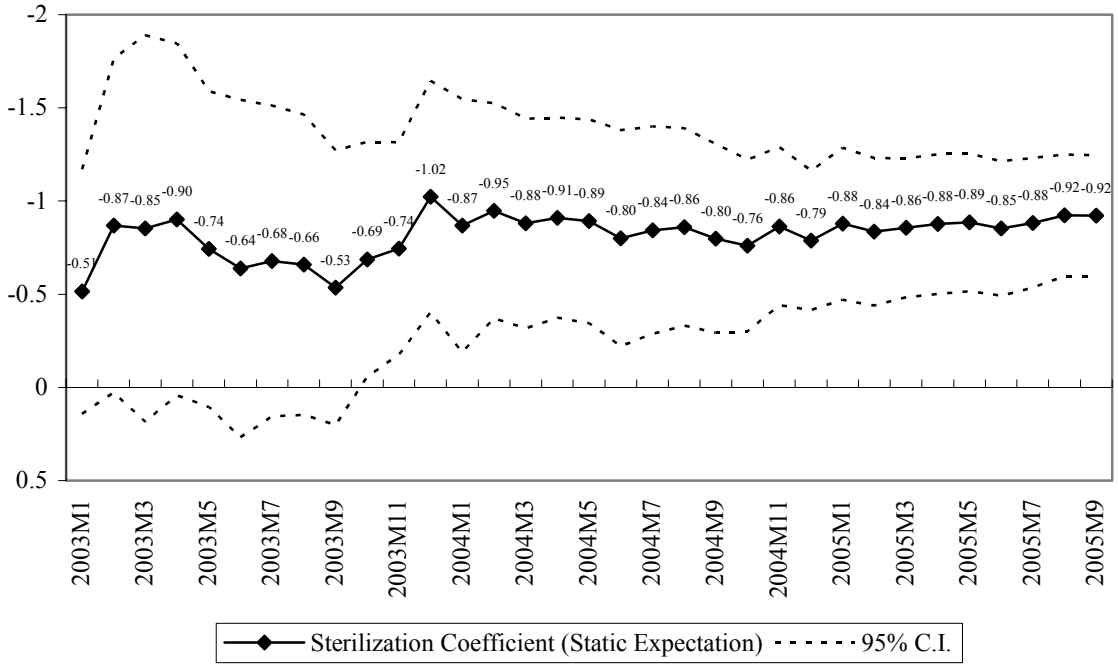
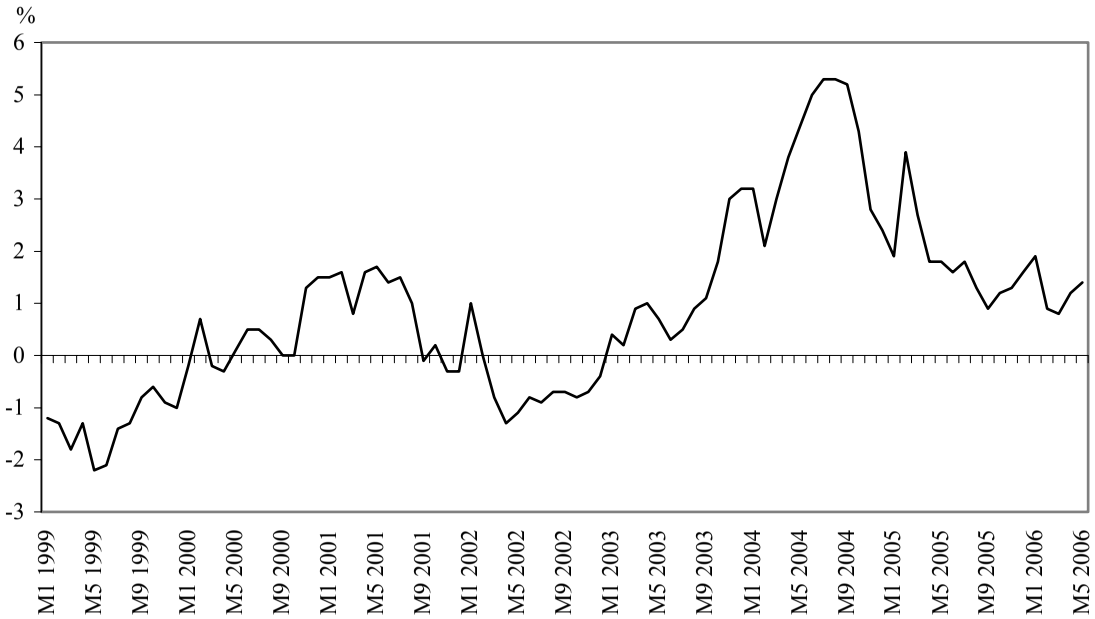


Figure 8: Inflation (CPI % Change) in China, 1999: M1 – 2006: M5



Source: IFS and TEJ Great China Database

Table 1: Definitions and Measurement of the Variables Used in Empirical Study

Variables	Definitions	Measured as	Data (Source)
NFA_t^*	Foreign reserves denominated in domestic currency minus foreign liabilities	$Reserve(\$) \times e_t^{CNY/\$}$ - *Foreign Liabilities(CNY)*	*IFS*
ΔNFA_t^*	The change in NFA_t^* excluding revaluation effect	$[\, NFA_t^* - NFA_{t-1}^*(\frac{e_t}{e_{t-1}}) \,]/GDP_t$	*IFS*
ΔNDA_t^*	The change in (net domestic assets + net other assets – capital item) +revaluation effect scaled by the GDP.	$[\, \Delta NDA_t + \Delta NOA_t - \Delta K_t + NFA_{t-1}^*(\frac{e_t}{e_{t-1}} - 1) \,]/\ GDP_t$	*IFS*
mm_t	Money Multiplier for M2	*M2/Monetary Base*	*IFS*
Δmm_t	The change in money multiplier for M2	$Log(mm_t) - Log(mm_{t-1})$	
$\Delta REER_t$	The change in Real Effective Exchange Rate.	$Log(REER_t) - Log(REER_{t-1})$	*IFS*
$y_{c,t}$	Cyclical Income. The real output deviated from its trend scaled by the trend. The trend is measured by HP-filter.	*[Log(Real GDP) – HP- filter trend] / HP filter trend*	*IFS and TEJ Great China Database*
Δp_t	Inflation Rate	$Log(cpi_t) - Log(cpi_{t-1})$	*TEJ Great China Database*
$\Delta(r_t^* + E_t e_{t+1})$	The change in exchanged adjusted foreign interest rate. The foreign interest rate is the interest rate for US 3-month treasury bill. $F_{3-month}$ is the 3-month non-deliverable CNY forward rate.	$\Delta[r_t^* + \ln(e_{t+1})]$ *if perfect foresight.* $\Delta[r_t^* + \ln(F_{3-month})]$ *if forward-looking* $\Delta[r_t^* + \ln(e_t)]$ *if Static expectation*	*IFS and Bloomberg*
ΔG_t	The change in government fiscal deficit scaled GDP	$\Delta G_t / GDP_t$	*IFS and Quarterly Monetary Reports Issued by the PBC*

Table 2: ADF Unit Roots Test for China Data (1999: M6 - 2005: M9)

Variables	Type of Test	ADF test Statistic (P-value) H_0 : Variable has a unit root
ΔNDA_t^*	Intercept	-7.199***(0.000)
ΔNFA_t^*	Intercept and trend	-8.785***(0.000)
Δmm_t	Intercept	-8.337***(0.000)
$\Delta REER_t$	Intercept	-7.171***(0.000)
$y_{c,t}$	Intercept	-6.500***(0.000)
Δp_t	Intercept	-8.057***(0.000)
$\Delta(r_t^* + E_t e_{t+1})$ (Perfect foresight)	Intercept	-5.224***(0.000)
$\Delta(r_t^* + E_t e_{t+1})$ (Forward-looking expectations)	Intercept	-7.726***(0.000)
$\Delta(r_t^* + E_t e_{t+1})$ (Static Expectations)	Intercept	-4.824***(0.000)
ΔG_t	Intercept	-9.746***(0.000)

Note: (*) Significant at more than 10 percent; (**) Significant at more than 5 percent; (***) Significant at more than 1 percent.

Table 3: Summary Statistics of Variables Used in Empirical Study (1999:M6-2005:M9)

Variables	N	Mean	Std. Dev.	Maximum	Minimum
ΔNFA_t^*	75	0.066	0.056	0.196	-0.109
ΔNDA_t^*	75	-0.022	0.140	0.345	-0.556
Δmm_t	75	0.003	0.025	0.091	-0.060
$\Delta REER_t$	75	-0.001	0.012	0.035	-0.024
$y_{c,t}$	76	0.000	0.065	0.135	-0.150
Δp_t	75	0.000	0.006	0.019	-0.014
$\Delta(r_t^* + E_t e_{t+1})$ (Perfect foresight)	75	-0.0005	0.003	0.003	-0.014
$\Delta(r_t^* + E_t e_{t+1})$ (Forward-looking expectations)	75	-0.0007	0.0039	0.0133	-0.0103
$\Delta(r_t^* + E_t e_{t+1})$ (Static Expectations)	75	-0.0005	0.003	0.003	-0.013
ΔG_t	75	-0.009	0.136	0.255	-0.615

Table 4: China -Estimated Simultaneous Equations, 1999: M6 – 2005: M9

China: 2SLS	Perfect Foresight: $E_t e_{t+1} = \ln(e_{t+1})$		Forward Exchange Rate: $E_t e_{t+1} = \ln(F_{3M,t})$		Static Expectation: $E_t e_{t+1} = \ln(e_t)$	
	ΔNFA_t^*	ΔNDA_t^*	ΔNFA_t^*	ΔNDA_t^*	ΔNFA_t^*	ΔNDA_t^*
Intercept	**0.062***	**0.052***	**0.064***	**0.057***	**0.061***	**0.052***
	(0.008)	(0.014)	(0.008)	(0.015)	(0.008)	(0.014)
ΔNDA_t^* (Offset)	**-0.630***	-	**-0.634***	-	**-0.710***	-
	(0.137)		(0.150)		(0.153)	
ΔNFA_t^* (Sterilization)	-	**-0.920***	-	**-0.968***	-	**-0.921***
		(0.164)		(0.181)		(0.166)
Δmm_t	**-2.632***	**-4.551***	**-2.680***	**-4.590***	**-2.974***	**-4.555***
	(0.764)	(0.389)	(0.790)	(0.389)	(0.814)	(0.391)
$\Delta REER_{t-1}$	-0.028	-	0.028	-	-0.001	-
	(0.442)		(0.437)		(0.538)	
$y_{c,t-1}$	**0.224***	0.137	**0.237***	0.145	**0.248***	0.138
	(0.127)	(0.152)	(0.124)	(0.148)	(0.144)	(0.152)
Δp_{t-1}	0.116	1.359	-0.053	1.083	0.326	1.319
	(0.848)	(0.883)	(0.833)	(0.860)	(0.877)	(0.886)
$\Delta(r_t^* + E_t e_{t+1})$	-0.156	-1.415	1.781	1.611	-0.062	-0.966
	(2.148)	(2.417)	(1.633)	(2.055)	(2.356)	(2.660)
ΔG_t	-	**-0.201****	-	**-0.207****	-	**-0.201****
		(0.080)		(0.080)		(0.080)
R-square	0.290	0.841	0.299	0.841	0.218	0.840
Adj. R-square	0.226	0.826	0.235	0.826	0.147	0.826

Note: (*) Significant at more than 10 percent; (**) Significant at more than 5 percent; (***) Significant at more than 1 percent.