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Housing Price Bubble, Sterilization and Foreign Exchange Accumulation in China

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摘要

2001 年以來，由於持續性的經常帳順差和資本流入，促成了中國外匯存底快速的累積。爲了維持人民幣匯率的穩定與經濟平穩發展，中國人民銀行實施了一連串的沖銷政策，以緩解因外匯占款所可能引起的流動性過剩與物價膨脹問題。然而，日益推升的沖銷成本對中國外匯沖銷的有效性與持續性將造成衝擊。因此，本論文第一部分即建構在個體基礎理論的架構下，將房價納入中國貨幣當局的目標函數，並檢視中國人民銀行沖銷政策的有效性與可持續性。實證結果顯示，近年來中國人民銀行幾乎完全沖銷了國際資本流入與外匯準備上升對基礎貨幣的影響，亦即資本流動程度的上升並未破壞中國貨幣政策的獨立性。然而，沖銷政策的可持續性分析卻顯示，中國人民銀行沖銷政策的可持續性於 2008 年 3 月開始受到嚴峻的挑戰，顯示出中國人民銀行承受了極大的沖銷不可持續性的壓力。

隨著短期國際資本流入快速增加以及在中國人民銀行無法完全沖銷因外匯干預所釋放出的外匯占款背景下，資產價格的上漲也逐漸引起人們對於短期國際資本流入與資產價格之間相互作用導致資產價格泡沫的質疑。爲了探討短期國際資本流入與中國資產市場之間的關係，本論文第二部分引入結構化向量自我迴歸模型來探究未沖銷完全的基礎貨幣與短期國際資本流入對中國股票市場與房地產市場的衝擊。實證結果顯示，中國的短期國際資金流入與資產價格上漲事實上爲一種自我實現與相互促進的關係，未沖銷完全的基礎貨幣會進一步推升資產價格上漲，顯示出短期國際資本的流入與流動性過剩的現象，將促使中國資產價格出現泡沫。

當資金極度充裕的時候，在中國大陸缺乏其它可以選擇的投資管道之下，將會助長股市與房市的投資與投機熱潮，也因而造成股票市場的波動與中國的房地產價格的快速成長。隨著中國近年來的改革開放與經濟發展，房地產業迅速發展成爲國民經濟的支柱產業，甚至已經成爲一些城市的經濟命脈。因而瞭解中國房

地產市場的發展情況並針對房價泡沫化作出判斷也因此成爲了刻不容緩的課題。

因此，本論文第三部分則延續第一部分及第二部分的議題，探討中國房地產市場的房價泡沫問題，並進一步利用狀態空間模型，結合卡門濾波器的遞迴運算，以最大概似法來估計泡沫價格。實證結果顯示，中國、北京、及上海的房地產市場確實存在房價泡沫的現象，中國房地產的泡沫價格占房價的比例雖然隨著中國政府的房地產政策調控而略有下降趨勢，但在2012年第4季，此比例仍高達27.99%的水準。此外，利用北京與上海民眾的可支配所與房價進行實證分析發現，北京與上海泡沫價格占房價的比例甚至超過了48%，顯見中國房地產市場房價泡沫問題的嚴重性。

Abstract

In the context of the constant buildup of China's foreign exchange reserves, the PBC has undertaken a series of sterilization operations to alleviate excessive liquidity and inflationary pressure resulting from huge funds outstanding for foreign exchange. However, the growing costs of sterilization have also impacted the effectiveness and sustainability of the foreign exchange surplus sterilization policy. Therefore, the first part of this dissertation is to examine the sterilization policy in China. Within a microeconomic framework, we incorporate the housing price variable into the target loss function of the monetary authority to explore its financial capabilities and evaluate the effectiveness and sustainability of China's sterilization policy. The empirical results show that Chinese monetary authorities sterilize almost all of the effects of international capital inflows and increasing foreign exchange reserves on the monetary base. That is, increased capital mobility does not sabotage the independence of the Chinese monetary policy. Nevertheless, analyses of the sustainability of sterilization policy indicate that the sustainability of the monetary sterilization policy has been seriously challenged since March 2008, which suggests that Chinese monetary authority has endured tremendous pressure for unsustainable sterilization.

In the context of rising foreign exchange reserves and monetary authorities being unable to sterilize all funds outstanding for foreign exchange due to foreign exchange market interventions, increases in asset prices have gradually made people question the interaction between short-term capital inflows and asset prices that contributes to asset price bubbles. In order to investigate the relationship between short-term international capital inflows and asset markets. A structural vector auto-regressive (SVAR) model is used to explore the effects of the incompletely sterilized monetary base and short-term international capital inflows on the Chinese stock markets and real estate markets in the second part of this dissertation. The empirical evidence demonstrates that the relationship between short-term international capital inflows and asset prices is self-fufilling and mutually reinforcing. The incompletely sterilized monetary base further exacerbates asset price bubbles, which suggests that short-term international capital inflows and excess liquidity will gradually escalate the severity of asset price bubbles.

With an over-abundance of funds and a shortage of other viable channels of investment in China, such circumstances tend to encourage investments and speculations in the stock market and real estate market. Consequently, this causes China's stock market to fluctuate and prices of real estate are being driven up in China. Following China's reform and economic development in recent years, the nation's

real estate industry has rapidly evolved into a pillar of China's national economy and the economic bloodline in some cities. As such, acquiring sufficient understanding of China's real estate market for an accurate assessment of the risk of a housing price bubble has become an issue that requires immediate attention.

In order to discuss the extent and severity of real estate bubbles in China. The third part of this dissertation uses the maximum likelihood method through the use of a state space model and recursive computation of the Kalman Filter to estimate the housing price bubbles in China. Results of empirical analyses reveal that price bubbles do exist in housing markets of Beijing, Shanghai and the whole of China in general. Although the proportion of price bubble to house price in China has shown a moderate decline due to the Chinese government's adjustment of its real estate policies, price bubbles remained as high as 27.99% in the fourth quarter of 2012. Empirical analyses of Beijing and Shanghai residents' disposable income and housing prices revealed that the proportion of price bubble to house price in the two cities has exceeded 48%, which suggests that housing price bubbles remain a significant issue to be addressed.

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Chapter 1
Introduction

With the adoption of market-oriented economic system reforms and the opening-up policy since 1978, China's economy has become increasingly integrated in the world economy. In the beginning of 1990s, China continued to adjust the exchange rate of the RMB and adopted a dual exchange rate system in 1994, thereby effectively steering the economic system to become export oriented. After China accepted current account convertibility in 1996 in accordance with an agreement with IMF, it joined the World Trade Organization in 2001. The country has witnessed rapid increase in its foreign trade and inflows of foreign direct investments. After the burst of East Asian financial crisis, China has been running a twin surplus in balance of payments for 13 consecutive years (1999-2011). Especially, the current account surplus experienced a rapid expansion from 2004 (USD 68.7 billion) to 2008 (USD 426.1 billion).

China has accumulated huge foreign exchange reserves, with an unprecedented total of about USD 3.3 trillion in 2012, as a result of a large and persistent trade surplus and foreign direct investment inflows over more than a decade. China's huge holding of foreign exchange reserves has produced some unavoidably high costs. Wang and Duncan (2013) pointed out that these costs include quasi-fiscal cost, opportunity cost, financial repression cost, resultant resource allocation inefficiency, and economic structure distortion cost.

While substantial growth in foreign exchange reserves, China's funds outstanding for foreign exchange have also grown steadily due to the government's efforts to alleviate the pressure on the RMB's appreciation. In order to stabilize money supply and to alleviate the risks of excess liquidity, inflation and asset price bubble, the People's Bank of China (PBC) started to issue central bank bills in June 2002. Their use has coincided with that of several other instruments for sterilization, including reserve requirements, open market operations of special government bonds and currency swaps with commercial banks. But as the Chinese government endeavored to alleviate the impact of the steep growth in foreign exchange reserves on domestic currency demand and liquidity through various sterilized intervention policies, the growing costs of sterilization have also impacted the effectiveness and sustainability of the foreign exchange surplus sterilization policy.

In the short term, the sterilized intervention could achieve both exchange rate stability and domestic monetary objectives, therefore solving the conflict between internal and external equilibrium (Obstfeld, 1982). However, although there are some

debates about whether sterilized intervention is sustainable. Calvo (1991) pointed out that currency sterilization causes a central bank's domestic debt to grow rapidly. If the central bank's domestic debt is not fully indexed to the price level, sterilization policies trigger a vicious cycle of inflation through massive accumulation of domestic debt. In other words, sterilized intervention should not be sustained. Dalton and Dziobek (2005) pointed out the massive sterilization will lead to the quasi-fiscal deficit of a central bank, which may hurt the central bank's independence or credibility.

The issues of effectiveness and sustainability of sterilization policy have been the subjects of debates in different circles. Despite the fact that China has successfully sterilized most of the impact of its growing foreign exchange reserves on the domestic money supply, the effectiveness of capital controls has been steadily declining and foreign exchange reserves have been constantly growing, resulting in rising costs of sterilization which have made sustainability of sterilization policies increasingly difficult.

Consequently, in order to examine the effectiveness of sterilization instruments adopted by the People's Bank of China, the first part of this dissertation has taken the approach proposed by Brissimis et al. (2002) to adopt microeconomic foundations for the construction of a model of sterilization and offset coefficients that fit China's monetary stance to evaluate the effectiveness of China's sterilization policies. Furthermore, after the analysis of China's sterilization policies, the study has modified Frenkel (2007) by using simple theoretical models to discuss the sustainability of China's sterilization policy.

In addition, the growth in foreign assets is creating problems for the operation of monetary policy, as the assets have to be sterilized, at least partially, to prevent excess liquidity and credit expansion will boost investment generating overcapacity, feed inflation of consumer prices or asset price bubbles. China's capital market has been intensified largely in size, breadth and depth in the past decade. Two markets mainly concerned are stock market and housing market. The variation of asset prices was striking in recent years. The massive short-term foreign capital inflows presents various dangers to China's economy since it can move very quickly in and out of a market, and has the potential to create bubbles in the stock market and real estate market. There is little evidence in the extant literature on the role of short-term foreign capital inflows in the recent evolvement of China's real estate market and stock market. Therefore, in the second part of this dissertation, we intend to uses a structural vector auto-regression (SVAR) model and includes a variable for the unsterilized portion of the monetary base. In addition to exploring the effects of short-term foreign capital inflows and the unsterilized portion of the monetary base on asset prices in

China, the extent to which rises in asset prices further attract short-term inflows of foreign capital is analyzed. These serve as references to maintaining financial stability in China.

The development process of China real estate market can be subdivided into four phases. The initiation and exploration phase from 1987 to 1991, the abruptly expansion phase from 1992 to 1993, the contraction and recession phase from 1994 to 1997, and the recovery and continuing expansion phase since 1998 (Liu and Huang, 2004). China fully opened its housing market in 1999. Since that time, housing prices in China have continued to grow rapidly. The high growth rate of house prices attracts substantial concern regarding the existence of price bubbles.

Expansion of credit has always been one of the leading causes of asset price inflation and burst of various bubbles in nations around the world. That said, as China's real estate market remains highly reliant on loans provided by the banking sector, it is only natural that significant amounts of risks have been steadily building up. The lending processes of financial institutions may also contribute to the creation of a speculative bubble. Properties are often used as collateral for loans. Thus, the loans from banks play a significant role in formation of housing bubbles primarily because the rise in housing prices directly increases the value of real estate collateral, thereby driving banks to offer more real estate loans. Evidence shows that excess credit plays an important role in the creation and persistence of a bubble (Allen, 2001; Herring and Wachter, 2003). Given the interdependent and intricate relationship between China's housing market and her financial sector, a crisis in the real estate market that may lead to liquidity risks in the banking sector can easily escalate into a full-blown financial crisis. As such, acquiring sufficient understanding of China's real estate market for an accurate assessment of the risk of a housing price bubble has become an issue that requires immediate attention.

It is generally believed that given the premise of rational expectations, actual asset prices ought to adhere to prices predicted by market fundamentals, and when actual prices deviate from market fundamentals, the discrepancy constitutes a bubble. For example, Case and Shiller (2003) define the asset price bubble is a price acceleration that cannot be explained in terms of the underlying fundamental economic variables. Different from the literature, the state equation is mainly used in the third part of this dissertation, to represent the correlation between observable and unobservable variables, whereas the signal equation describes the trends of unobservable variables. Since real estate bubbles are an unobservable variable, a state space model has been chosen, in conjunction with recursive computation of the Kalman Filter, for estimation of the unobservable variable (bubble). The maximum likelihood estimation is used to avoid issues of inappropriate model specification and

address difficulties in predicting the extent of deviation between prices and market fundamentals that have been apparent in existing literature. It can help us determine if asset prices have in fact deviated from market fundamentals in China's real estate market.

The remainder of this dissertation will proceed in following fourth chapters. In chapter 2, within a microeconomic framework, we incorporate the housing price variable into the target loss function of the monetary authority to explore its financial capabilities and evaluate the effectiveness and sustainability of China's sterilization policy; in chapter 3, we employ a SVAR model is used to explore the effects of the unsterilized portion of the monetary base and short-term international capital inflows on the Chinese stock markets and real estate markets; in chapter 4, we use the maximum likelihood method through the use of a state space model and recursive computation of the Kalman Filter to estimate the housing price bubbles in Beijing, Shanghai and the whole of China; and finally, the main results of each chapter and some important implications are summarized in chapter 5.

Chapter 2

The Effectiveness and Sustainability of the Sterilization Policy in China

2.1 Introduction

Ever since the start of economic reforms in 1978, China's economic system has gradually shifted towards capitalism and globalization, with steady growth in the volume of foreign trade and a large number of foreign investments in the country. In the beginning of 1990s, China continued to adjust the exchange rate of the RMB and adopted a dual exchange rate system in 1994, thereby effectively steering the economic system to become export oriented. After China accepted current account convertibility in 1996 in accordance with an agreement with IMF, it joined the World Trade Organization in 2001. The country has witnessed rapid increase in its foreign trade and inflows of foreign direct investments.

However, during the process of actual management of its economy, the monetary authority is usually forced to adopt conflicting currency policies in order to maintain the stability of its currency's internal and external value. In his theory of impossible trinity, it is impossible simultaneously to have full capital mobility, fixed exchange rate and an independent monetary policy. In recent years, with RMB appreciation expectation and anticipation of increase in value of RMB denoted assets, inflows of short-term international capital into China have risen steadily as the issue of the impossible trinity looms over the nation.[1]

By the end of June 2012, China's foreign exchange reserves had reached USD 3,240.01 billion, equivalent to 70.84% of the People's Bank of China's total assets at that point of time. While substantial growth in foreign exchange reserves, China's funds outstanding for foreign exchange have also grown steadily due to the government's efforts to alleviate the pressure on the RMB's appreciation. During the period from 2003 to 2012, China's funds outstanding for foreign exchange have grown by as much as 10.61 times; the growth margin constitutes 99.11% of the increase in narrow money M1 in the same period.[2] In order to stabilize money supply and to alleviate the risks of excess liquidity, inflation and asset price bubble, the

[1] In order to keep the value of the RMB stable, the People's Bank of China has to constantly interfere with the foreign exchange market by making purchases, which has resulted in expansion of the monetary base. On the other hand, in order to suppress potential inflation that might accompany the overheated investment flows since 2003, the People's Bank of China had to keep the speed of expansion of the monetary base and credit, thereby resulting in conflicting goals of maintaining RMB stability and preventing overheating of the economy.

[2] See the Chinese State Administration of Foreign Exchange, http://www.safe.gov.cn/.

People's Bank of China (PBC) has implemented various policies such as issuance of central bank bills, raising reserve requirement ratio, implementing loan allocations and so forth.

But as the Chinese government endeavored to alleviate the impact of the steep growth in foreign exchange reserves on domestic currency demand and liquidity through various sterilized intervention policies, the growing costs of sterilization have also impacted the effectiveness and sustainability of the foreign exchange surplus sterilization policy. Starting from 2002, the scale of bill issuance by the People's Bank of China has expanded drastically and the proportion of the monthly balance of central bank bills against the bank's total debt skyrocketed from 2.91% in 2002 to 22.11% in 2008.[3] Although the scale of bill issuance slowed in 2011, the proportion was still at 8.31%.[4] The cost of interest paid by the People's Bank of China for sterilization (using bank bills) reached its peak at RMB 8,639 billion in 2008. Despite having gradually decreased over time, the cost of such operations still reached RMB 2,761 billion in 2011. With the interest that the People's Bank of China has to cover for the reserve requirement, the costs of issuing central bank bills and raising the reserve requirement ratio as tools for sterilization was RMB 3,005 billion in 2011 (equivalent to 14.95% of China's foreign exchange reserve for the same year). These serve as apparent signs that the sustainability of China's sterilization policies faces tough challenges.[5]

The issues of effectiveness and sustainability of sterilization policy have been the subjects of debates in different circles. Despite the fact that China has successfully sterilized most of the impact of its growing foreign exchange reserves on the domestic money supply, the effectiveness of capital controls has been steadily declining and foreign exchange reserves have been constantly growing, resulting in rising costs of sterilization which have made sustainability of sterilization policies increasingly difficult. Inadequate sterilization is resulting in excessive money supply and liquidity, causing influx of funds into the asset market, thereby causing asset prices to rise steadily.

After introduction, the second section of this paper offers a brief overview of relevant research conducted on sterilization policies, while the third section aims to shed light on the current status of foreign exchange reserves accumulation and sterilization instruments used in recent years. The fourth section focuses on empirical models, and the fifth section covers the data and empirical results, followed by conclusions of this study.

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[3] The monthly balance of central bank bills is defined as the value of the current issuance of central bank bills minus the value of maturing central bank bills.

[4] See the People's Bank of China, http://www.pbc.gov.cn/.

[5] Calculated based on the statistics published by the People's Bank of China.

2.2 Literature Review

Whether a nation adopts a fixed foreign exchange rates or a managed floating exchange rate system, its monetary authorities must inevitably rely on foreign exchange market intervention as a means of maintaining exchange rate stability. When faced with a surplus in balance of payments, monetary authorities strive to maintain existing exchange rates by purchasing foreign exchange in the market while releasing high power domestic currency of equivalent value. But in order to achieve the target exchange rate and maintain domestic credit stability, monetary authorities also implement sterilized intervention policies to offset the additional money supply that comes from the increase in funds outstanding for foreign exchange. Starting from 1994, China's foreign exchange reserve has grown rapidly due to a surplus in balance of payment and as a result, the People's Bank of China has been searching and deploying new sterilization tools to maintain stability of RMB exchange rate and domestic credit. Among the currency sterilization tools, including re-lending (1994-2001) and national debt sterilization (1998-2002) adopted by the bank, the two most important tools frequently deployed by the People's Bank of China are central bank bill sterilization (2002-present) and reserve requirement ratio adjustment (2006-present).

The key that determines the success of sterilized intervention made by a nation's monetary authority for effective foreign exchange market adjustment and maintenance of exchange rate stability lies in sustainability of the intervention. For nations that implement sterilized intervention, as the volume of funds outstanding against foreign exchange grows, the central bank faces increasing difficulty in implementation of sterilized intervention due to the huge costs and the declining effectiveness of monetary policy decision making-process.[6] In the discussion on the effectiveness of sterilization manipulation, Frankel (1994) analyzed four factors that can trigger capital inflows in developing counties and maintained that sterilized intervention widens the interest spread between domestic and foreign markets, thereby accelerating the growth of funds outstanding for foreign exchange and money supply, making it even more difficult to achieve the given sterilization goal.[7] Not only that, it

[6] The huge costs of foreign exchange sterilization are mainly due to the massive replacement of foreign currency assets by domestic bonds caused by the central bank's sterilization operations in the open market. This raises the interest rates of domestic bonds while lowering the rate of return on foreign currency assets. The domestic and foreign interest rate spread results in substantial deficit for the central bank and may even partially offset the bank's sterilization efforts.

[7] The four factors include: (1) Foreign interest rate reduction – foreign capital would flow to developing nations to ensure higher rates of return; (2) in order to alleviate inflationary pressure, nations with capital inflows raise domestic interest rates that to appeal to foreign capital; (3) increased domestic money demand due to various reasons, thereby driving up interest rates, which appeals more

affects the independence of the nation's monetary policies. Reinhart and Reinhart (1999) believe sterilization manipulations drive domestic interest rates further up and attract more foreign investments, thereby making sterilization even more difficult and rendering the operation extremely costly. And as such, governments should either give up or reduce the scale of sterilization operations, or even opt to control capital mobility as an alternative solution.

Spiegel (1995) developed an open-economy version of the Bernanke-Blinder model which indicates that sterilization efforts through increases in reserve requirements have limited impact if viable financial alternatives to the commercial banking sector exist. After having studied cases of sterilization in seven emerging economies in Asia (Indonesia, Korea, Malaysia, Philippines, Singapore, Taiwan and Thailand), he found Korea to be in possession of the largest nonbank financial sector and that in times of high international capital inflows, the monetary authority in Korea had limited success with its approach of sterilizing inflowing capital by open market manipulation and increased reserve requirement ratio.

Caballero and Krishnamurthy (2001) constructed a theoretical model to validate the ineffectiveness of currency sterilization, and went one step further to discuss the opposite effect of short-term capital inflows as the consequence of sterilization policies. Their research pointed out that when a country lacks the connection with the international financial market, sterilization policies may elevate the risks of liquidity and result in continued inflow of short-term capital, which leads to increase in money supply and over-appreciation of domestic currency.

Glick and Hutchison (2009) analyzed the impact of sterilization of central bank bills on the base currency in China and the empirical results revealed that the sterilization coefficient is within the interval from -0.6 to-1.5. However, starting from the fourth quarter of 2006, due to China's constantly growing foreign exchange reserve, the effectiveness of sterilization policies started to decline and this led to the rapid growth of reserve money. Zhang (2012) survey the various estimations about China's sterilization coefficient from 1994 to 2009. The estimate of sterilization coefficient after 2003 is within the interval from -0.996 to-0.852 (significant at more than 5%), which indicates that PBC's sterilization has been quite successful in maintaining the independence of domestic money and credit growth after the introduction of central bank bills and reserve requirement ratio.

With sterilized intervention policies growing in strength, sustainability of sterilization operations has become an important issue. Calvo (1991) pointed out that currency sterilization causes a central bank's domestic debt to grow rapidly. If the

to foreign capital; and (4) changes in external conditions that lead to improved trade balance, thereby increasing domestic exports. As a result, total domestic demand increases and thereby creates pressure to increase domestic interest rate.

central bank's domestic debt is not fully indexed to the price level, sterilization policies trigger a vicious cycle of inflation through massive accumulation of domestic debt. In other words, sterilized intervention should not be sustained. Therefore, the government should issue domestic bonds at corresponding price levels to alleviate inflationary pressures. Christensen (2004) used a vector auto-regression (VAR) model that incorporated domestic credit, foreign exchange reserve, domestic interest rate, foreign interest rate and so forth for analysis of correlation between massive capital inflows and sterilized intervention in the Czech Republic from 1993 to 1996. Results of the study revealed that sterilized intervention for neutralizing effects of capital inflows proved to be successful initially. But with the progression of time, elevated domestic interest rates eventually attract more capital inflows, thereby raising the cost of sterilized intervention and ultimately rendering the policy unsustainable.

Sterilization was virtually a game between the Czech Republic's commercial banks and its central bank. The commercial banks would borrow loans from international market at low interest rates and invest in domestic sterilization bonds that offered a higher rate of return. And thus, given the conditions of significant interest rate spread between domestic and foreign market and limited controls on capital, the Czech monetary authority was essentially encouraging more inflows of short-term capital with its sterilization operations.

Using simultaneous equations, Ouyang and Ramkishen (2005) empirically validated the correlation between domestic net assets and foreign net assets, in addition to an analysis of China's foreign exchange reserves, structure of its sources and the consequences of the nation's currency policies in the 1990s. Findings from the research showed that China's sterilized intervention policies were unsustainable due to the substantial burden on the nation's treasury and actually produced the opposite results due to escalation of capital inflows and fragility of the financial system as time passed. Mohanty and Turner (2005) indicated that between 2000 and 2004, the central banks of Korea, the Czech Republic and Israel issued currency-stabilizing bonds of values equivalent to 300%, 200% and 150% of their respective reserve money for the purpose of sterilization operations. Issuance of central bank bonds on such massive scale not only increases the difficulty of currency management for the central bank but also raises the expenditure on interest payment when domestic interest rates go up, which renders sterilization operations too costly to last.

Based on the relevant international experience, most monetary authorities around the world that engage in sterilization manipulation in the open market tend to drive up the level of domestic interest rates (Reinhart and Reinhart, 1999). If a nation's economy is not in synchronous with (or even goes against) foreign economies in terms of trends of change, it can possibly attract more international capital arbitrage,

which can further widen the gap between domestic and international economic indicators. More space for arbitrage encourages more capital inflows and ultimately creates a vicious cycle that renders sterilization manipulation measures unsustainable.

The existing literature mostly focuses on analysis of sterilization coefficient estimation or sustainability of the sterilization policy. With the exception of the sterilization model, little research is based on microeconomic frameworks in the circumstance of today. With sterilization policies that are unsustainable and cannot be used to sterilize all of the effects of international capital inflows and increasing foreign exchange reserves on the monetary base, the expectation of the RMB's appreciation would trigger and attract more foreign capital to China, thereby further impacting the currency policies, economy and capital markets. In order to examine the effectiveness of sterilization tools adopted by the People's Bank of China, the study has taken the approach proposed by Brissimis et al. (2002) to adopt microeconomic foundations for the construction of a model of sterilization and offset coefficients that fit China's monetary stance to evaluate the effectiveness of China's sterilization policies. Secondly, with analysis of China's sterilization policies completed, the study has modified Frenkel's (2007) basis of argument by using simple theoretical models to discuss the sustainability of China's sterilization policy.

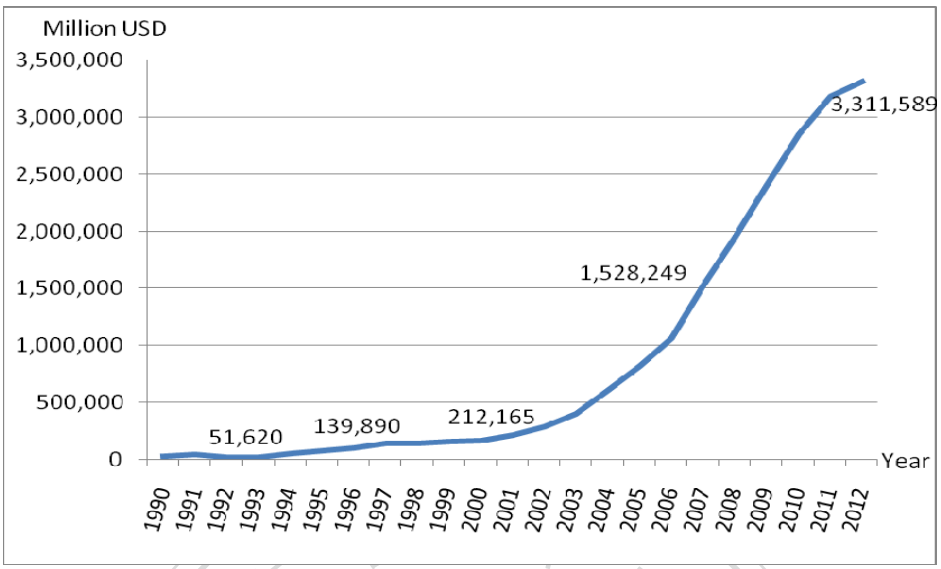
2.3 Accumulation of Foreign Exchange Reserve and Sterilization Instruments in China

The PBC foreign exchange reserves have been increased continuously since 1993, an increase of 188.69 billion USD by 1997, at an average annual growth rate of 52.96%. Due to incessant current account surpluses and capital inflows from 2003 until 2007, with an average annual increase of about 194.67 billion USD in foreign exchange reserves, China overtook Japan to become the world's largest holder of foreign exchange reserves in 2006. At the end of 2012, China's foreign exchange reserves amounted to 3,311.59 billion USD, accounting for approximately 30.28% of the world's total foreign reserves.[8]

The continuing accumulation of foreign exchange reserves has substantially exacerbated pressure on RMB to appreciate. Driven by the expected appreciation of RMB, large amounts of foreign direct investment (FDI) and short-term international capital have flowed into China, leading increases in foreign exchange settlement in the capital account. In order for the People's Bank of China to stabilize its foreign exchange rates, it continues to purchase excess supply of foreign exchange in the foreign exchange market, resulting in excess liquidity in the domestic money market

[8] See International Monetary Fund (IMF), http://www.imf.org/external/index.htm.

and rising inflationary pressure.



Source: TEJ database.

Figure 2.1: Accumulation of Foreign Exchange Reserve in China —2000 to 2012

Table 2.1 shows that funds outstanding for foreign exchange were only 1,429.11 billion RMB in 2000, accounting for 39.16% of the base money. However, the figure surged to 25,853.35 billion RMB in 2012, accounting for up to 102.45% of the reserve money. This indicates that the independence of monetary policy of Chinese monetary authorities has been severely challenged.

In the context of the constant buildup of China's foreign exchange reserves, the PBC has undertaken a series of sterilization operations to alleviate excessive liquidity and inflationary pressure resulting from huge funds outstanding for foreign exchange. Owing to the small size of the market for treasury bonds, the PBC has started issuing central bank bills for sterilization, in addition to open market operations such as outright sales of government bonds and repurchase agreements. The official launch of issuance of central bank bills by the PBC was on April 22, 2003. The central bank bills' balance has progressively increased, from 303.16 billion RMB in 2003 to 4,577.98 billion RMB in 2008. While this has gradually decreased in recent years, the balance was still RMB 1,388 billion by the end of 2012 (Table 2.1).

Table 2.1: Funds Outstanding for Foreign Exchange, Reserve Money and the Monthly Balance of Central Bank Bills

Unit: billion RMB

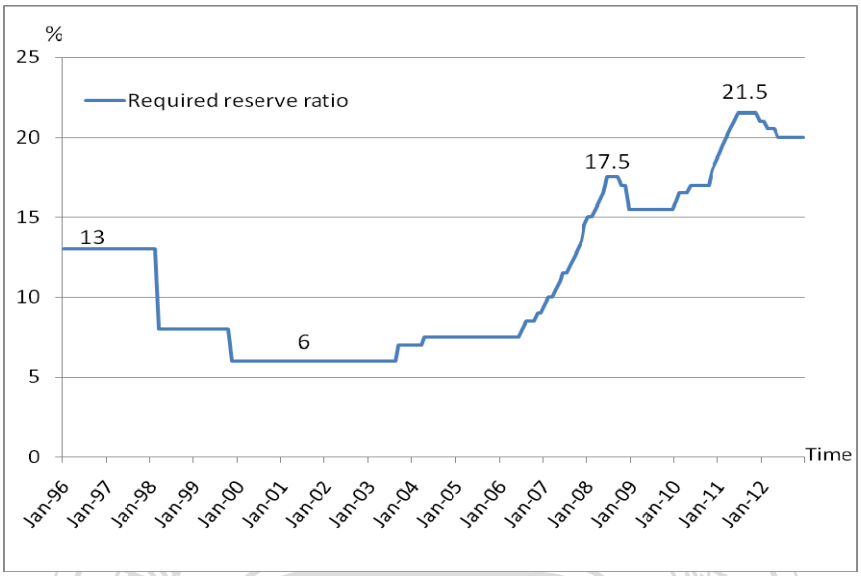
	Funds Outstanding for Foreign Exchange (1)	Reserve Money (2)	Proportion (3) = (1)/(2) (%)	Balance of Central Bank Bills
2000	1,429.11	3,649.15	39.16	--
2001	1,785.64	3,985.17	44.81	--
2002	2,322.33	4,513.82	51.45	148.75
2003	3,484.69	5,284.14	65.95	303.16
2004	5,259.26	5,885.61	89.36	1,107.90
2005	7,121.11	6,434.31	110.67	2,029.60
2006	9,898.03	7,775.78	127.29	2,974.06
2007	12,837.73	10,154.54	126.42	3,446.91
2008	16,843.11	12,922.23	130.34	4,577.98
2009	19,311.25	14,398.50	134.12	4,206.42
2010	22,579.51	18,531.11	121.85	4,049.72
2011	25,358.70	22,464.18	112.89	2,333.67
2012	25,853.35	25,234.52	102.45	1,388.00

Source: People's Bank of China, http://www.imf.org/external/index.htm.

Faced with unceasing pressures of excessive liquidity due to balance of payments surplus, the PBC has strengthened liquidity management of the banking system as the main objective of its monetary policy in 2006, coupled with the use of other sterilization instruments such as open market operations and reserve requirement ratio, etc., in order to suck the excess liquidity out of the banking system. In addition to issuance of central bank bills along with the repo operations for increasing the intensity of open-market sterilization operations, the PBC, facing rapid growth in domestic credit, adjusted the reserve requirement ratios 41 times between March 1998 and March 2012 (Figure 2.2). The PBC lowered the reserve requirement ratios only seven times during this period, when facing the Asian financial crisis, the U.S. subprime mortgage crisis, and the problem of sluggish economy in 1998, 2008 and 2011, respectively. The PBC raised the reserve requirement ratios for rest of the period to deal with the issue of excess liquidity. By the end of 2012, the reserve requirement ratios for large and small and medium-sized financial institutions were 20% and 16.5%, respectively.

Relatively a huge proportion of the monetary base is released during the process of intervening in the foreign exchange market by the PBC. In order to achieve the goals of its monetary policy and alleviate inflationary pressure, the PBC intervenes in the foreign exchange market and at the same actively adopts sterilization measures,

for neutralizing the impacts of excess liquidity due to increasing foreign exchange reserves through opposite changes in the net domestic assets, thereby maintaining steady growth of money supply.



Source: Same as Figure 2.1.

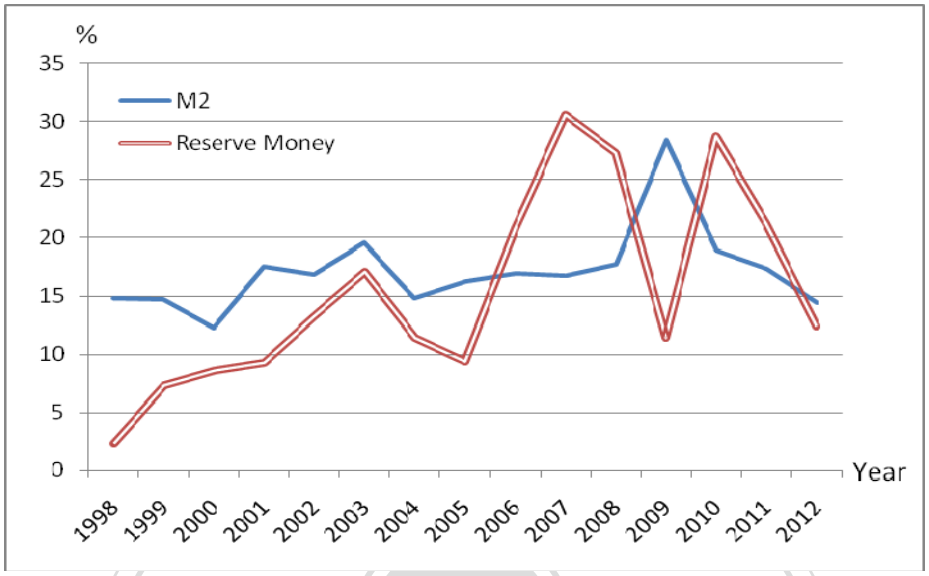
Figure 2.2: Change of Required Reserve Ratio in China

Figure 2.3 shows that the monetary base experienced rapid growth and fluctuations from 1998 to 2012, soaring to its highest of 30.59% in 2007 from 2.29% in 1998. The broad money supply M2 relatively maintained a steady growth from 1998 to 2008, at an average growth rate of 16.23%, and started to experience significant fluctuations since 2008.

The steady growth of M2 proves that Chinese monetary authorities effectively sterilize the impacts of capital inflows and increasing foreign reserves on the domestic money supply. That is, large-scale foreign exchange market intervention and sterilization operations have significant influence on the money supply in China. However, volatile fluctuations of M2 after 2008 also pose challenges to the sustainability of China's sterilization policy.

While sufficient foreign exchange reserves help stabilize the economy, excessive foreign reserves may create tremendous pressure on the monetary authorities. In the face of lacking elasticity in exchange rates, the central bank opts to convert the external pressure on RMB to the internal momentum for monetary expansion. Nonetheless, with expanding balance of payments surplus, excessive foreign reserves held by the PBC incur interest costs of sterilized intervention, opportunity costs of inefficient allocation of capital and exchange rate risk. Furthermore, as the problem of excess money can be temporarily avoided by sterilization measures, operations for

sterilization in the medium-to-long term may still result in risks such as overheating of the economy, inflation and asset price bubbles.



Source: CEIC database.

Figure 2.3: Growth Rate of Reserve Money and M2 — 1998 to 2012

2.4 Empirical Model

Guided by the trends of financial liberalization and globalization, the domain of international financial markets has witnessed significant reforms in 20th century. With China becoming more and more open to the rest of the world, international capital has continued to converge in China. In order to maintain the stability of the RMB exchange rate, the PBC has been making large purchases of foreign exchange and passively releasing base currency while implementing sterilization policies to prevent and suppress inflation. Transnational capital flow and unsterilized portion of the monetary base have not only triggered drastic fluctuations in asset pricing, but can further escalate into a full-blown financial crisis due to the risks of financial market liquidity.[9] And as such, it is imperative for one to gain a deeper understanding of the effectiveness and sustainability of China's sterilization policies.

The empirical model is divided into two parts. First, a model of offset and sterilization coefficients that fits China's monetary stance was constructed based on microeconomic foundations to evaluate the effect of China's sterilization policy.

[9] The unsterilized portion of the monetary base is defined as the current funds outstanding for foreign exchange minus the net value of the current issuance of central bank bills and the net value of the reserve requirements.

Second, a simple theoretical model was used to explore the sustainability of sterilization policy of the People's Bank of China, and to determine whether the PBC can control domestic money supply without sacrificing the policy's credibility. The following section describes each empirical model.

2.4.1 Effectiveness of the Sterilization Policy

Most of the studies in extant literature have failed to provide solid microeconomic foundations when specifying models for offset and sterilization coefficient estimation, leading to less stringent choices of control variables. The present study aims to construct, with reference to the model of Brissimis et al. (2002), a theoretical framework to better reflect the working of China's economy to evaluate the effectiveness of the sterilization policy in China.

Brissimis et al. (2002) assumed that the central bank has an objective function (a loss function), including the squared deviation of the current exchange rate from its target, the squared deviation of the logarithm of the price level from its target, the squared deviation of real income from its trend, a measure of the volatility of interest rates and a measure of the volatility of exchange rates.

Maintaining the stability of price level and economic growth is the priority for China's monetary authorities. Considering China's currently managed floating exchange rate system and interest rate policy, we assume that the target loss function of China's monetary authorities includes the squared deviation of the price level from its target and the squared deviation of real income from its trend. In addition, as real estate in China has been an important investment target, China has recently taken a considerable number of policy measures to maintain stable housing prices and to avoid economic impacts resulting from volatility of housing prices. Therefore, the target loss function of China's monetary authorities is defined as follows:[10]

$$L_t = \alpha\left(p_t - p_t^T\right)^2 + \beta\left(Y_t - Y_t^T\right)^2 + \gamma\left(H_t - H_t^T\right)^2, \quad (1)$$

where p_t, Y_t, and H_t denote inflation rate, gross domestic product and housing prices at period t, respectively; p_t^T, Y_t^T and H_t^T are the target and trend values of each variable.

In order to simplify the loss function in Equation (1), we substitute $Y_{c,t}$ and $H_{c,t}$ for $Y_t - Y_t^T$ and $H_t - H_t^T$, respectively, and subtract p_{t-1} from both p_t p_t^T.

[10] With a shortage of other viable channels of investment in China, real estate market and stock market are main asset markets in China. As China recently only took a considerable number of policy measures to maintain stable housing prices but did not take any policy for stock market. Therefore, the target loss function of China's monetary authorities only contain the variable of cyclical housing price and put the variable of yields of foreign investment in Equation (5).

Δp_t^T is assumed to be zero.[11] We can rewrite Equation (1) in a slightly different form, as follows:

$$L_t = \alpha(\Delta p_t)^2 + \beta(Y_{c,t})^2 + \gamma(H_{c,t})^2, \quad (2)$$

where L_t is the loss function of the monetary authority at the end of time t; Δp_t is the change in the inflation rate at time t; $Y_{c,t}$ is the cyclical income at period t and $H_{c,t}$ is the cyclical housing price at period t. The central bank has an objective to minimize the loss function in Equation (2) in order to obtain the optimal foreign exchange market intervention rule ΔNFA_t and domestic money market intervention rule ΔNDA_t. The constraints that reflect the working of the economy in China for the monetary authorities' loss function are analyzed in turn.

Cyclical Income

For the specification of cyclical income, we follow the theoretical formulation outlined in Brissimis et al. (2002) and hypothesize that the cyclical income depends on the change in money supply and the stance of the government's fiscal policy. The equation takes the following form:[12]

$$Y_{c,t} = \varpi_1[(\Delta NFA_t + \Delta NDA_t)mm_t + MB_t \Delta mm_t] + \varpi_2 Y_{c,t-1} + \varpi_3 \Delta G_{c,t}, \quad (3)$$

where $\varpi_1 > 0$, $0 < \varpi_2 < 1$ and $\varpi_3 > 0$. ΔNFA_t and ΔNDA_t are the changes in the net foreign assets and net domestic assets, respectively; Δmm_t is the change in money multiplier; and MB_t is the monetary base. Besides, $G_{c,t}$ represents the stance of government fiscal policy, which is measured by the budget deficit as percent of GDP.

Inflation

Since China trades with other countries frequently, inflation in China is hypothesized to depend not only on the change in money supply and inflation of previous period but also on the impacts of exchange rate volatility. China often uses deposit reserves and interest rate policy, influencing the money multiplier through the liquidity of commercial banks, to affect money supply. As a result, the constraint for inflation is defined as follows:[13]

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[11] In order to simplify the analysis, after subtracting p_{t-1} from both p_t and p_t^T, we can get $p_t - p_t^T$ equals to $\Delta p_t - \Delta p_t^T$.

[12] Since the volume of central bank's net other assets and equity capital are smaller, we assume that $MB_t = NFA_t + NDA_t$ to simplify the analysis.

[13] We first assume that $\Delta p_t = \gamma_1 \Delta M_{2t} + \gamma_2 \Delta p_{t-1} + \gamma_3 \Delta e_t$, where $M_{2t} = MB_t \cdot mm_t$ is the money supply M_2 at time t. $\Delta p_t = \gamma_1[(\Delta NFA_t + \Delta NDA_t)mm_t + MB_t \Delta mm_t] + \gamma_2 \Delta p_{t-1} + \gamma_3 \Delta e_t$ can be derived by using the specification in footnote 12.

$$\Delta p_t = \tau_1\left[(\Delta NFA_t + \Delta NDA_t)mm_t + MB_t\Delta mm_t\right] + \tau_2\Delta p_{t-1} + \tau_3\Delta e_t, \quad (4)$$

where $\gamma_1 > 0$, $0 < \gamma_2 < 1$ and $\gamma_3 > 0$. Δp_{t-1} and Δe_t are inflation rate in the previous period and change in the exchange rate at the current period. In addition to the above specification, we set the following constraint specifically for Δe_t:[14]

$$\Delta e_t = -c\lambda_0 + (c + c\lambda_1\omega_1 mm_t)\Delta NFA_t + (c\lambda_1\omega_1 mm_t)\Delta NDA_t +$$

$$(c\lambda_1\omega_1 MB_t)\Delta mm_t + (c\lambda_1\varpi_2)Y_{c,t-1} + (c\lambda_1\varpi_3)\Delta G_{c,t} + (c\lambda_2)\Delta REER_{t-1} +$$

$$\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)], \quad (5)$$

where $REER_{t-1}$ is the real effective exchange rate in time $t-1$; e_t is the exchange rate at time t; Ee_{t+1} is the expected exchange rate at time $t+1$; r_t is the domestic interest rate; r_t^* is the foreign interest rate; $r_{s,t}$ and $r_{s,t}^*$ are yields of domestic and foreign investment, respectively.

This equation includes a number of well-known propositions. First, an increase in foreign exchange reserves as a result of intervention to sell the domestic currency causes Δe_t to increase. Second, an increase in the domestic component of the monetary base causes Δe_t to increase. Third, an increase in the money multiplier causes the interest rate to decline and hence the domestic currency to depreciate. Next, an increase in cyclical income is likely to cause imports to increase and hence cause Δe_t to increase. In addition, the higher fiscal deficit indirectly decreases export and increases import, and thus the domestic currency to depreciate.

Furthermore, the real effective exchange rate is calculated as a weighted average of real exchange rates of the national currency to the currencies of its main trading partners. Generally speaking, the United State is the biggest trade partner of China, thus, the change in the real effective exchange rate will lead Δe_t to increase. Finally, an increase in the expected rate of depreciation, a decrease in the interest rate spread, and a fall in the investment yield of stocks spread will cause Δe_t to increase as capital flows out of domestic assets.

Substituting Equation (5) into Equation (4) obtains:

$$\Delta p_t = (\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)\Delta NFA_t + (\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)\Delta NDA_t +$$

$$(\tau_1 MB_t + \tau_3 c\lambda_1\omega_1 MB_t)\Delta mm_t + \tau_2\Delta p_{t-1} + (\tau_3 c\lambda_1\varpi_2)Y_{c,t-1} +$$

$$(\tau_3 c\lambda_1\varpi_3)\Delta G_{c,t} + (\tau_3 c\lambda_2)\Delta REER_{t-1} + \tau_3\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)]. \quad (6)$$

[14] The derivation of Equation (5) see Appendix A.

Cyclical Housing Price

For the specification of cyclical housing price, it is hypothesized that the cyclical housing price depends on the change in money supply and the cyclical housing price in the previous period. Therefore, the constraint for cyclical housing price takes the following form based on the assumptions in footnote 12:

$$H_t = \phi_1\left[(\Delta NFA_t + \Delta NDA_t)mm_t + MB_t \Delta mm_t\right] + \phi_2 H_{t-1}. \quad (7)$$

Under a typical managed floating exchange rate system, we hypothesize that monetary authorities minimize its loss function by altering domestic credit and undertaking exchange rate intervention. Consequently, the following two equations can be derived by solving for the partial derivatives $\partial L_t / \partial \Delta NFA_t = 0$ and $\partial L_t / \partial \Delta NDA_t = 0$, subject to the constrains in Equations (3), (6) and (7):[15]

$$\Delta NFA_t^* = \pi_1 + \pi_2 \Delta NDA_t^* + \pi_3 \Delta mm_t + \pi_4 \Delta p_{t-1} + \pi_5 H_{c,t-1} + \pi_6 Y_{c,t-1} +$$

$$\pi_7 \Delta G_{c,t} + \pi_8 \Delta REER_{t-1} + \pi_9 \Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)], \quad (8)$$

$$\Delta NDA_t^* = \theta_1 + \theta_2 \Delta NFA_t^* + \theta_3 \Delta mm_t + \theta_4 \Delta p_{t-1} + \theta_5 H_{c,t-1} + \theta_6 Y_{c,t-1} +$$

$$\theta_7 \Delta G_{c,t} + \theta_8 \Delta REER_{t-1} + \theta_9 \Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)]. \quad (9)$$

These two equations are used in the current regression model to examine the effectiveness of the monetary authority's sterilization policy. In order to be in line with the assumption of model stability and exclusion of irrelevant factors from the original variables' specifications, definitions of the variables are modified.

In Equations (8) and (9), ΔNFA_t^* is the change in the adjusted net foreign assets scaled by GDP;[16] ΔNDA_t^* is the change in the adjusted net domestic asset scaled by GDP;[17] Δmm_t is the change of money multiplier for M2 in logarithmic terms; Δp_{t-1} is the change of consumer price index in logarithmic terms in time (t-1); $H_{c,t-1}$ is the

[15] The derivation of Equations (8) and (9) see Appendix B.

[16] There is no correlation between changes in net foreign assets and changes in the monetary base and capital mobility due to non-policy factors such as interest rate volatility and interest income. Therefore, the resulting changes in asset values due to interest rate volatility and interest income are excluded from the change in the net foreign assets. The change in the net foreign assets due to RMB exchange rate appreciation is $RE_t = NFA_{t-1}[(e_t - e_{t-1})/e_{t-1}]$, where e_t is the monthly exchange rate (RMB to USD) at time t. The interest income of the foreign exchange reserves is $\gamma_t = (i_{TB_t}/12)\cdot[(NFA_{t-1} + NFA_t)/2]$, where i_{TB_t} is the U.S. 10-year Treasury yield. Therefore, we specify the adjusted net foreign assets scaled by the monthly GDP as $NFA_t^* = (NFA_t - RE_t - \gamma_t)/GDP_t$.

[17] Using the specification in footnote 12, $NDA_t^* = (MB_t/GDP_t) - NFA_t^*$ is the adjusted net domestic asset scaled by the monthly GDP.

cyclical housing price index in time (t-1); $Y_{c,t-1}$ is the cyclical income in time (t-1);[18] $\Delta G_{c,t}$ is the change in government expenditure scaled by GDP; $\Delta REER_{t-1}$ is the change of the REER in logarithmic terms; Ee_{t+1} is the expected nominal exchange rate (foreign currency per US dollars) in logarithmic terms.[19] $(r_t - r_t^*)$ is the interest rate differential between People's Bank of China and the U.S. Federal Funds and $(r_{s,t} - r_{s,t}^*)$ is the stock return differential between China and the U.S.

π_2 in Equation (8) is the offset coefficient of regressing capital flows on the monetary policy.[20] When $\pi_2 = 0$, capital is immobile, which means that the impact of a change in net domestic assets on the domestic money supply is substantial. When $\pi_2 = -1$, capital is perfectly mobile, indicating that the effect of a change in net domestic assets on the domestic money supply can be completely offset by capital mobility and thus independence of the monetary policy of the central bank is undermined. In general, capital flows is less than perfectly mobile and thus we expect that $-1 < \pi_2 < 0$.

In addition to the offset coefficient, there are seven control variables in Equation (8). Increases in inflation and cyclical housing prices lead to an expected currency depreciation; an increase in the money multiplier causes domestic money supply to increase and hence the interest rate too declines; an increase in government deficit leads to a decrease in trade surplus; all of these four factors result in decrease in foreign capital inflows. We thus expect π_3, π_4, π_5 and π_7 to be smaller than 0.

Furthermore, an increase in cyclical income is likely to not only cause imports to increase and thus the trade surplus and foreign exchange reserves to decrease, but also boost the confidence of foreign investors. This thereby encourages capital inflows. The real effective exchange rate increases, causing the trade surplus and the foreign exchange reserves to decrease while at the same time the domestic currency appreciates. This leads to inflows of foreign speculative capital. Expectations of RMB's appreciation increase the upward pressure on RMB, which then attracts inflows of foreign capital. A decrease in the interest rate spread, a fall in the investment yield of domestic stocks and a rise in the investment yield of foreign stocks increases relative USD yields, negatively affecting capital inflows. As a result, we expect these three coefficients, π_6, π_8 and π_9, to be either positive or negative.

θ_2 in Equation (9) is the sterilization coefficient of the monetary policy. When

[18] $H_{c,t-1}$ is calculated as the proportion of housing price minus housing price trend against house price trend, and $Y_{c,t-1}$ is calculated as the proportion of GDP minus GDP trend against GDP trend. Hodrick-Prescott (HP) filter method is used to measure the trend of each variable in our study.

[19] The 3-month RMB/USD non-deliverable forward rate (NDF) in logarithmic terms is used to substitute Ee_{t+1}.

[20] The offset coefficient is the effect of a change in central bank net domestic assets on domestic money supply that was offset by the capital inflows.

$\theta_2 = -1$, it represents that the PBC can sterilize all effects of international capital inflows and increase in foreign exchange reserves on the monetary base, meaning that a change in net foreign assets of central bank leads to a change of the same magnitude but in the opposite direction in net domestic assets. The effect of capital mobility on the monetary base is completely sterilized, resulting in no change in the monetary base. $\theta_2 = 0$ means the absence of sterilization, indicating that the central bank does not change the volume of domestic assets as a means of sterilization in response to a change in foreign assets. As China's current monetary situation is usually somewhere in the continuum of these two extremes, we expect that $-1 < \theta_2 < 0$.

In addition to the sterilization coefficient, there are seven control variables in Equation (9). The central bank usually implements a tight monetary policy in response to a rise in the money multiplier and increase in inflation, the cyclical housing price, the cyclical income and the government fiscal deficit. We hence expect coefficients θ_3, θ_4, θ_5, θ_6 and θ_7 to be smaller than zero.

Moreover, a stronger upward pressure on RMB will force the monetary authorities to implement an expansionary monetary policy to alleviate the pressure on RMB. A decrease in the interest spread between domestic and foreign markets, a decrease in the investment yield of domestic stocks, and a rise in the investment yield of foreign stocks reduce foreign capital inflows. The central bank then implements a tight monetary policy in order to maintain a stable exchange rate. We therefore expect that θ_9 could be positive or negative.

2.4.2 Sustainability of Sterilization Policy

Generally speaking, sustainability refers to the capacity to maintain a process or a state. High costs of sterilization undermine the central bank's solvency, further affecting investors' confidence in credibility of the central bank, rendering the sterilization operations unsustainable. Three methods have been often employed in the literature to examine the effect of sterilization costs on sustainability of sterilization. The first method defines net sterilization cost as the interest on the central bank's bills minus the U.S. treasury bill rate. This ignores the impact of the exchange rate on sterilization costs and uses only the direct costs as an indicator of sustainability of sterilization. The second method is relatively stringent. It considers the relationship between the interest rate of the central bank's bills and the growth rate of GDP. However, there is no direct relationship between the credibility of the central bank and GDP growth. Hence the current study takes the third approach to analyze sustainability of sterilization policy. We discuss the relationship between central bank's sterilization costs and its holdings of foreign exchange reserves.

As nowadays China mostly depends on raising the reserve requirement ratios and

issuing central bank bills as sterilization instruments, only the third method is used (Frenkel, 2007) to explore sustainability of sterilization bills. The present study uses a simple theoretical model to analyze the sustainability of PBC's sterilization by drawing on the methodology outlined in Frenkel (2007) and modifying its theoretical arguments.[21]

The credibility of monetary policy is based on the assets held by the central bank. When sterilization is by way of central bank's bills and reserve requirement ratios, the central bank's principal assets include foreign exchange reserves, and its principal liabilities include monetary base, interest payments on its bills and interest payments on deposit reserves. We assume that the change of total central bank assets is as follows:

$$dA = dRE = RdE + EC + ErR, \tag{10}$$

where dA is the change in total central bank assets, R, E, r and C are the foreign exchange reserves, the exchange rate, the yield of foreign exchange reserves, and the foreign currency bought by the central bank as part of intervention for maintaining stability of the exchange rate, respectively. RE is the foreign exchange reserves denominated in domestic currency. Besides, the change in the foreign exchange reserve denominated in domestic currency include RdE, EC, and ErR, which represent gains and losses due to exchange rate volatility, new additions to foreign exchange reserves and the return earned on the original foreign exchange reserves, respectively.

Besides, we assume that the change of total central bank liabilities in response to the sterilization policy takes the following form:

$$dP = dB + dL + d\tilde{R}, \tag{11}$$

where dP is the change in the total liabilities of the central bank, dB is the monetary base released due to exchange rate intervention, L and $\tilde{R}$ are the debts incurred by issuance of central bank bills and reserve requirements as two instruments of sterilization policy, respectively. iL and $\tilde{r}\tilde{R}$ represent the interest on central bank bills and reserve requirements, respectively. When denominating these terms in domestic currency, Equation (11) can be rewritten as follows:

$$dP = EC + iL + \tilde{r}\tilde{R}. \tag{12}$$

In order to avoid high sterilization costs that may threaten the sustainability of

[21] In the context of China's financial system, monetary policy is often different from the operations in the Western countries. Qunatitative instruments (reserves) are preferred over price instruments (intereste rate). China has raised the reserve requirement ratios several times in recent years in an attempt to recover the funds outstanding for foreign exchange; therefore, the model specification has to take into account the increases in central bank liabilites due to the adoption of deposit reserve policy.

sterilization operations and policy credibility, we assume sustainable sterilization is required when the increase of liabilities is smaller than or equal to the increase of foreign exchange reserve:

$$EC + iL + \tilde{r}\tilde{R} \le RdE + EC + ErR,$$

crossing out EC and then dividing by RE for both sides of the above equation yields:

$$i(L/RE) + \tilde{r}(\tilde{R}/RE) \le (RdE/RE) + (ErR/RE),$$

multiplying (RE/L) gives:

$$i + \tilde{r}(\tilde{R}/L) \le (e + r)(RE/L), \tag{13}$$

where $e = dE/E$. Equation (13) represents the rule for sustainability of the sterilization policy; the left-side of the equation can be viewed as the ratios of sterilization cost of the central bank; the right-hand side represents adjusted yields of foreign exchange reserves. Specifically, E is the nominal exchange rate (foreign currency per US dollars); i and L are interest rate on 3-months central bank bills and the monthly balance of central bank bills; r and RE are yield on 3-month U.S. Treasury bills and the value of foreign exchange reserve expressed in RMB, respectively, and $\tilde{r}$ and $\tilde{R}$ are the interest on required reserves and reserve requirements, respectively.

2.5 Data and Empirical Results

In this section, empirical analysis has been conducted with an offset and sterilization coefficient model to examine the process of international capital flows and the effectiveness of monetary policies. A framework that can be used to analyze sustainability of sterilization policies adopted by the PBC based on the correlation between its sterilization costs and China's foreign exchange reserve is proposed.

2.5.1 Data Description and Unit Root Tests

There are two parts in the empirical analysis. The empirical data in the first part contains a total of 134 observations from February 2002 to March 2013. That in the second part has a total of 103 observations from June 2003 to December 2011. As the smallest accounting frequency is quarterly for China's published GDP, the monthly GDP data employed in the present study is derived by decomposing the quarterly GDP, weighted by the ratio of monthly gross industrial output to the quarterly gross industrial output.

Since there is no differentiation between the reserve requirements and excess

reserves in the balance sheet of the PBC, it is difficult for us to calculate the exact amount of interest payments by the PBC on the reserve requirements and excessive reserves. As a result, we use the deposits with central bank from the balance sheet of other depository corporations as an alternative variable representing the reserve requirements. We then use the corresponding ratios of reserve requirement to obtain the approximate amount of monthly interest payments by the PBC. Table 2.2 summarizes the measurement and sources of the various data used in the estimating equations.

Table 2.2: Variables and Data Sources

Variable	Data Source
$\Delta NFA_t^* : \frac{\Delta[NFA_t - NFA_{t-1}(\frac{e_t - e_{t-1}}{e_{t-1}}) - (\frac{i_{TB_t}}{12})(\frac{NFA_{t-1} + NFA_t}{2})]}{GDP_t}$	CEIC database
$\Delta NDA_t^* : \frac{\Delta MB_t}{GDP_t} - \Delta NFA_t^*$	CEIC database
$\Delta mm_t : \ln\left(\frac{M_{2,t}}{MB_t}\right) - \ln\left(\frac{M_{2,t-1}}{MB_{t-1}}\right)$	CEIC database
$\Delta p_{t-1} : \ln(CPI_t) - \ln(CPI_{t-1})$	CEIC database
$H_{c,t-1} : \frac{(\text{Housing price})_{t-1} - (\text{Housing price trend})_{t-1}}{(\text{Housing price trend})_{t-1}}$	CEIC database
$Y_{c,t-1} : \frac{(GDP)_{t-1} - (\text{GDP trend})_{t-1}}{(\text{GDP trend})_{t-1}}$	CEIC database
$\Delta G_{c,t} : \left(\frac{\text{fiscal deficit}}{GDP}\right)_t - \left(\frac{\text{fiscal deficit}}{GDP}\right)_{t-1}$	CEIC database
$\Delta REER_{t-1} : (REER)_t - (REER)_{t-1}$	TEJ database
Ee_{t+1} : The 3-month RMB/USD non-deliverable forward rate in logarithmic terms	Bloomberg
$r_t - r_t^*$: The interest rate differential between People's Bank of China and the U.S. Federal Funds	TEJ database
$r_{s,t} - r_{s,t}^*$: The stock return differential between China and the U.S.	CEIC database and TEJ database
i: Interest rate on 3-months central bank bills	PBC
$\tilde{r}$: The interest on required reserves	PBC
L: The value of the current issuance of central bank bills minus the value of maturing central bank bills	PBC
$\tilde{R}$: The deposits with central bank from the balance sheet of other depository corporations	PBC
RE: The value of foreign exchange reserve expressed in RMB	CEIC database
e: The rates of change in exchange rate	CEIC database
r: The yield on 3-month U.S. Treasury bills	TEJ database

This study has adopted the Augmented Dickey-Fuller (ADF) method of Dickey and Fuller (1979) to test whether the time series is stationary. The results are listed in Table 2.3. The results of ADF unit root tests reveal that all variables are stationary at the 5% level of significance.

Table 2.3: Unit Root Test for Effectiveness of the Sterilization Policy

Variable	τ Statistic
ΔNFA_t^*	-10.21***
ΔNDA_t^*	-11.15***
Δmm_t	-10.27***
Δp_{t-1}	-5.22***
$H_{c,t-1}$	-3.66***
$Y_{c,t-1}$	-2.27**
$\Delta G_{c,t}$	-4.07***
$\Delta REER_{t-1}$	-8.897***
$\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)]$	-12.05***

Note: ** and ***denote that the τ statistic is significant at 5% and 1% levels, respectively.

2.5.2 Empirical Results

Effectiveness of the Sterilization Policy

Equations (8) and (9) are simultaneous equations. Simultaneous equation system is considered to be more theoretically stringent. Nevertheless, considering China's economy is in transition, sound market operations and transmission mechanism have not existed among various economic variables. Simultaneous equations cannot be used to analyze the functional relationships among various economic variables representing structural characteristics of the economic system. In addition, if the endogeneity problems of ΔNFA_t^* and ΔNDA_t^* are not serious, results obtained from simultaneous equation estimation may not be necessarily better than those obtained by using the generalized least squares method.

In order to further confirm the correlation between ΔNFA_t^* and ΔNDA_t^*, a causality test has been conducted (Table 2.4). Based on the results in Table 2.3, there is no causal relationship between ΔNFA_t^* and ΔNDA_t^*. Accordingly, we use the generalized least squares method to estimate Equations (7) and (8).[22]

[22] Granger (1969) defined causality among variables based on a "prediction" perspective. In addition to considering past values of x variable when predicting x_t, if past values of y variable help predict

Table 2.4: Granger Causality Test Result

Null Hypothesis	Chi-sq.	Prob.
ΔNFA_t^* does not Granger Cause ΔNDA_t^*	0.24453	0.9507
ΔNDA_t^* does not Granger Cause ΔNFA_t^*	0.31366	0.9189

Table 2.5 shows results of estimations of the empirical model obtained through the use of the generalized least squares method. From Table 2.4, the offset and sterilization coefficients of international capital flows on monetary policy are -0.717 and -0.831, respectively.[23] These indicate that 70% of the change in net domestic assets of the central bank was offset by a negative change in the net foreign assets and 80% of the change in net foreign assets of the central bank was offset by a negative change in net domestic assets. This suggests that implementation of the large-scale sterilization by the PBC was effective.

In addition, coefficients of money multiplier are statistically significant and negative in all regressions. It is shown that a rise in the money multiplier increases the money supply and pushes interest rate down, leading to outflows of foreign capital. China's monetary authority is inclined to adopt a tight monetary policy to offset the increase in money supply caused by a higher money multiplier. The coefficients of the cyclical income in both equations are significantly negative, indicating the higher is the real output exceeding the potential output, the larger is the resulting negative impact on the current account surplus than the attraction of foreign capital. The monetary authority also tends to implement a tight monetary policy to suppress excessive growth of the economy. Moreover, the effect of government budget deficit on the net domestic credit is significantly different from zero. This indicates that in order to maintain the stability of the social system, the central bank adopts a tighter monetary policy stance in response to increases in the government budget deficit.

Furthermore, the effects of previous inflation volatility on net foreign assets and net domestic credit are not negative, as expected. The possible reason is that China in recent years has experienced rapid economic growth, accompanied by rising inflation. Foreign investors who are optimistic about China's economic outlook go to seek investment opportunities in China, leading to increases in net foreign assets. In order

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x_t, then y variable granger-causes variable x_t. When the Granger causality test shows that y variable does not granger-cause x variable, it cannot be viewed as variable y does not help explain x_t variable. It can only be used to determine lead-lag relationship between variables.

[23] The empirical result is similar to Glick and Hutchison (2009) and Zhang (2012) survey of the various estimations about China's sterilization coefficient from 2003 to 2009. High levels of sterilization indicates that PBC's sterilization has been quite successful in maintaining the independence of domestic money and credit growth after the introduction of central bank bills and reserve requirement ratio.

to maintain a stable foreign exchange market, the central bank cannot help inject money in the domestic market, even if coupled with sterilization operations.

Therefore, coefficients of the change of consumer price index in logarithmic terms in time (t-1) are statistically significant and positive in all regressions. The other variables are generally insignificant in the regressions and have inconsistent signs. These findings, statistically insignificant or with incorrect signs of the variable coefficients may be due to the fact that while the dependent variables are fairly volatile, the independent variables are quite stable.[24]

Table 2.5: Parameter Estimates

	ΔNFA_t^*	ΔNDA_t^*
Intercept	0.063***	0.045***
ΔNFA_t^*	—	-0.831***
ΔNDA_t^*	-0.717***	—
Δmm_t	-3.479***	-4.691***
Δp_{t-1}	2.506**	3.003**
$H_{c.t-1}$	-0.055	0.070
$Y_{c,t-1}$	-0.147**	-0.124*
$\Delta G_{c,t}$	-0.051	-0.082*
$\Delta REER_{t-1}$	-0.550	-0.335
$\Delta[Ee_{t+1}-(r_t-r_t^*)-(r_{s,t}-r_{s,t}^*)]$	0.002	-0.021
$\overline{R}^2$	0.586	0.884
DW	1.979	2.072

Note: ** and ***denote that the z statistic is significant at the 5% and 1% levels, respectively.

We also apply LM test and ARCH test to each equation to ensure the accuracy of the empirical model. The results are presented in Table 2.6. LM and ARCH tests show that the null hypotheses of no serial correlation and heteroscedasticity cannot be rejected at the 5% level of significance. Besides, CUSUM values fall within the two critical lines at the 5% significance level. Therefore, these equations are statistically stable.

Table 2.6: Residual Diagnostics

	ΔNFA_t^*		ΔNDA_t^*	
	Statistic	Prob.	Statistic	Prob.
LM Test	0.947	0.504	0.836	0.613
ARCH Test	0.444	0.942	0.118	0.999

[24] Since Equations (8) and (9) are derived by the theoretical model, the control variables cannot be chosen completely arbitrary. Accordingly, we cannot use robust test to test the robustness of the model.

Sustainability of Sterilization Policy

From the perspective of the central bank's financial resources, sustainability of sterilization operations depends on whether the central bank can make a profit. If the central bank is in surplus, the profit from its role as issuer of the currency exceeds the cost of sterilization operations, which are thus sustainable. On the contrary, if the cost of sterilization is too high and profitability of the central bank is compromised, sustainability of the sterilization policy is questionable.

As changes in the value of foreign assets due to exchange rate fluctuations do not correspond to the cash flow in the current period, this does not bring substantial pressure on the central bank in the short term. If we specify the short-term model without including gains and losses from exchange rate volatility, operations of sterilization policies might be sustainable. However, exchange rate volatility in the long run reduces the value of foreign exchange reserves relative to the domestic assets. When considering changes in the value of foreign exchange reserves because of exchange rate volatility, it is likely that sterilization is unsustainable.

For an overview of the ratios of sterilization cost and adjusted yields of foreign exchange reserves, we examine the sustainability of China's monetary sterilization policy based on the estimation of Equation (13) and the result is depicted in Figure 2.4. Figure 2.4 shows the ratios of sterilization cost were lower than the adjusted yields of foreign exchange reserves until March 2008. Afterwards, there are changes. The ratios of sterilization cost were higher than the adjusted yields of foreign exchange reserves between March and June, while the former was lower than the latter from July to September. Except for January 2009 and August 2010, the ratio of sterilization cost and the adjusted yields of foreign exchange reserves in the rest of the periods do not meet the requirements of Equation (13).[25]

There have been major changes in the balance sheet of the PBC in recent years. The growth of foreign exchange reserves is larger than the development of the economic system. Currency in circulation accounts for only a small portion of the central bank's liabilities; the major parts are the domestic liabilities that require payment of interest. This adds to the financial burden of the PBC and also results in increasing uncertainty of PBC's surplus.

[25] The financial crisis that began in 2007 spread and gathered intensity in 2008, the global response to the financial crisis began to take shape in late 2008. On October 8, 2008, the world's major central banks, including the Federal Reserve, the European Central Bank, the Bank of England, and the PBC, lowered interest rates in unison. Since the short/medium term foreign interest rate has dropped sharply, investment yields earned on foreign assets cannot cover PBC's interest payments on the outstanding PBC bonds and on the total (required and excess) reserves after late 2008. Thus, a projection of the sterilization cost and the income from foreign reserves investment also indicates the sterilization policy of PBC will become unsustainable in the future.

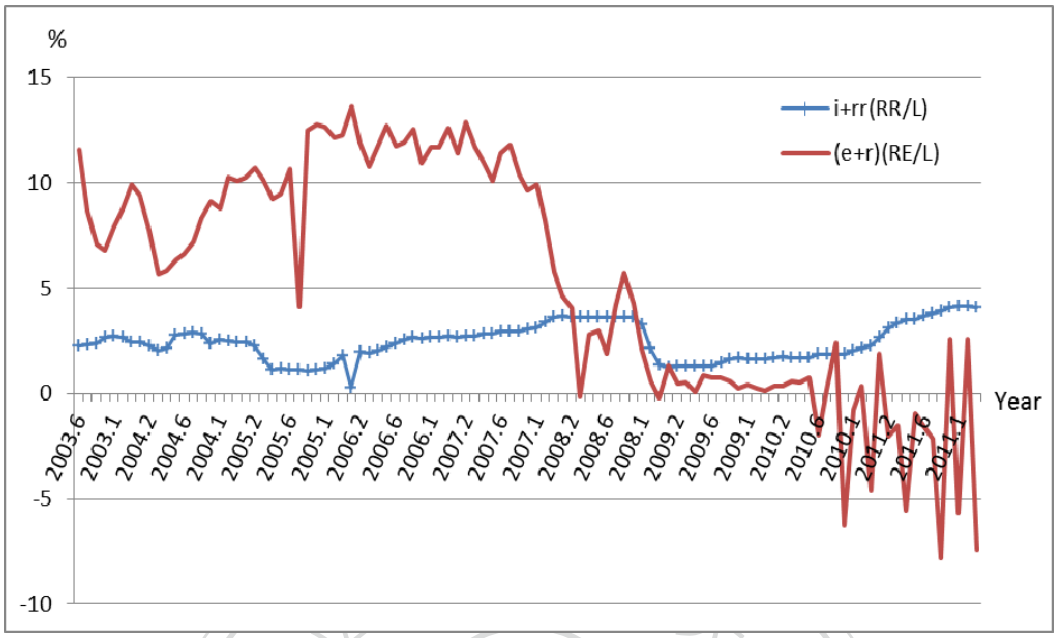


Figure 2.4: Determination of Sustainability of Monetary Sterilization

In addition, issuance of central bank bills only helps ease the problem of short-term excess liquidity. If the PBC continues to issue central bank bills as a sterilization measure in the long-run, it will further increase its financial burden. Furthermore, while the adjustment of reserve requirement ratios strengthens the autonomy of PBC and effectiveness of sterilization policy, long-term sterilization activities push up the interest rate in the financial market. This further encourages inflows of foreign capital which in turn neutralize the effectiveness of the sterilization policy. The resultant costs increase the difficulties in implementing the monetary policy.

Based on the foregoing analysis, sterilization operations undertaken by the monetary authorities in China have been increasing in recent years. This not only pushes up the market interest rate but also brings about imbalance in the asset structure of the monetary authorities, resulting in a vicious cycle of monetary policies. The sterilization costs are positively related to the yield of central bank's bills and the required deposit reserve ratio, and negatively related to the yields of foreign investments. As a result, in the current environment of economic downturn in Western countries and lower yields of foreign investment, adoption of sterilization policy further adds to burdens of the monetary authorities. Under the current international economic environment, sterilization will become unsustainable over a long period of time, in the future. As a consequence, the imbalance in the international balance of payment will inevitably have to be adjusted.

2.6 Summary

To stabilize the exchange rate of the RMB and further realize sustainable development of China's economy in the context of persistent balance of payments surplus and the intensified upward pressure on the RMB, the PBC uses a variety of sterilization measures and foreign exchange market interventions to reduce excess liquidity and maintain the stability of RMB exchange rate and the monetary policy independence.

Based on microeconomic foundations and with the perspective of minimizing the target loss function of monetary authorities, this study aims to construct a refined model for offset and sterilization coefficient estimation to evaluate the effectiveness of China's sterilization policy. Besides, empirical data are used to further explore financial capabilities of the central bank in order to understand the sustainability of the sterilization policy. The empirical results show that Chinese monetary authorities sterilize almost all effects of international capital inflows and increase in foreign exchange reserves on the monetary base. That is, increase in capital liquidity does not sabotage the independence of the Chinese monetary policy. Nevertheless, analyses of sustainability of the sterilization policy indicate that the sustainability of the monetary sterilization policy has been seriously challenged since March 2008.

In the context of rising costs of sterilization, massive and persistent international capital inflows have made it difficult for the PBC to achieve its twin goals of currency stability and monetary policy independence. In light of these circumstances, the monetary authority should not only adjust the maturity structure of the central bank bills to ease the pressure for making interest payments, but also actively develop diversified sterilization tools to compensate for the inadequate effects of sterilization measures. Moreover, the monetary authority should relax restrictions on capital outflows and adjust the imbalance in the balance of payments. Furthermore, this should help improve the exchange rate system and mechanism for adjusting the exchange rate to adjust the external imbalance of the economy, expand the ratio of foreign reserves held by enterprises and for gradually abolishing the provision on "allowable foreign exchange working position" for designated banks. These measures can alleviate pressure on the PBC for its passive role in the foreign exchange market interventions.

The persistent balance of payments surplus has eroded the autonomy of the central bank. As a result the Chinese government should focus on policy coordination. In addition to increasing the issuance of government bonds and raising the proportion of government bonds within the monetary authority's assets, coupled with effective

exchange rate management to control for speculative foreign investment, the government has to adjust the corresponding macroeconomic policy in order to effectively address the economic and asset bubbles due to excess liquidity.

Chapter 3

Short-term International Capital Inflows and Asset Markets in China

3.1 Introduction

In the context of globalization and internationalization, short-term international capital constantly flows across borders in search of arbitrage opportunities in the flourishing international capital market. Governments have gradually started paying attention to the resulting effects and impacts on their capital markets. In response to RMB appreciation expectations, the wide interest rate spreads and a generally optimistic outlook of China's economy, a considerable short-term international capital has flown into China in recent years, largely in the hope of making arbitrage profits in the domestic capital market.[1] In 2011, foreign investment in real estate development enterprises stood at 78.52 billion RMB, up by 96.21 percent over that in 2006. Direct investment in the property market by foreign investors was 38.65 billion RMB, up 127.53 percent over that in 2006.[2]

The People's Bank of China has continuously followed a sterilization policy along with foreign exchange market intervention, to stabilize the foreign exchange market. With inadequate sterilization, the increase in funds outstanding for foreign exchange due to the inflows of short-term international capital result in increased domestic money supply, further pushing up property prices. While short-term foreign capital inflows bring about capital mobility, there are already ample funds in the real estate market in China. Consequently, such capital inflows, to a certain extent, result in housing bubbles in some areas.

In addition, by sterilized intervention on a massive scale, the Chinese government has inevitably increased the risks of the financial sector. Since the People's Bank of China has mandated higher reserve requirement ratios, it not only weakens the autonomy of commercial banks but also lowers the profit margin for banks due to limitations of credit growth. In order to secure their existing market shares, commercial banks are forced to lower their loan standards or turn towards high-risk investments, which may render the loan conditions for specific industries too lax. With an over-abundance of funds and a shortage of other viable channels of investment in China, such circumstances tend to encourage investments and

[1] While the capital account in China has not yet been fully opened up, foreign capital can still flow into its capital market through associated channels.

[2] See National Bureau of Statistics of China, *China Statistics Annual Report*.

speculations in the stock market and real estate market. Consequently, this causes China's stock market to fluctuate and prices of real estate are being driven up in China.

And as such, despite the various tight monetary policies that the Chinese government has adopted, the scale of mortgage businesses of banks remains steadily on the rise. According to the statistics from the People's Bank of China, the real estate loan surplus in June 2012 for major financial institutions, rural cooperative financial institutions, urban credit cooperatives and foreign capital banks came to a total of 11.32 trillion RMB (a growth of 10.3% compared to the same period in 2011). Balance of land development loans, real estate loan balance and individual housing loans came to 803.7 billion RMB, 2.92 trillion RMB and 7.49 trillion RMB, with growth of 0.8%, 11.3% and 11%, respectively, compared to the same period in 2011. The ratio of China's real estate development completed investment against the nation's GDP has grown steadily over the years; by the end of June 2012, the ratio came to 13.48%. These figures reflect the flourishing development of China's real estate market.[3]

With this kind of huge investment in the real estate market, housing prices in various Chinese cities have risen considerably; some cities have even experienced a housing market bubble. Given the limited effectiveness of various sterilization tools deployed by the People's Bank of China, the increase in funds outstanding for foreign exchange due to inadequate sterilization create additional base currency and money supply, thereby amplifying the inflationary pressure for general goods and commodities. Not only that, this also creates a source of funding for real estate that causes inflation. It propels rapid growth in housing prices across major Chinese cities and creates higher risks of housing market bubbles.

Considering the overall current state of the real estate market in China, authorities have implemented an array of policies to suppress rising house prices. Short-term international capital lurking in the real estate market has started to flow out of the country, leading to collapse in the real estate market. For ensuring the development of real estate market in China does not suffer, understanding the current status of China's real estate market and the relationship between foreign capital and housing price are the pressing issues.

After introduction, the second section of this paper presents a quick overview of relevant research works and literature, which discuss the relationship between short-term international capital inflow and asset price. The third section provides a concise summary of short-term international capital inflows and asset markets in recent years, and the fourth section focuses on the empirical model. The fifth section

[3] See National Bureau of Statistics of China, *China Statistics Annual Report.*

covers the data description and empirical results, followed by conclusions of this paper.

3.2 Literature Review

Moderate international capital inflows can boost economic growth of a nation. Nevertheless, excessive short-term capital inflows impact the country's asset market, even leading to serious economic crises at times.[4] Financial booms and crises in emerging economies are tightly linked to international capital inflows. Large capital flows into emerging markets lead to a financial boom in host countries. On the other hand, when large amounts flow out, the lead to a crisis. Weak macroeconomic fundamentals are one of the major reasons for capital out-flows from emerging markets in the form of hot money. Domowitz et al. (1997) found that hot money from abroad had significantly affected stock price increases and market capitalization in Mexico, and had contributed to the 1994 Mexican financial market turmoil to a great extent. Sarno and Taylor (1999) examined the view that 1997 East Asian crisis was precipitated by bursting of asset price bubbles, which had been fuelled by strong capital inflows that were largely the result of a moral hazard problem in financial intermediation and the situation was exacerbated by a vicious cycle of asset price deflation and incipient and actual capital flight.

Foreign exchange rate is an important channel that connects domestic and international economies and globally experience has shown the close correlation between foreign exchange rates and real estate prices. Given that sterilization policies are unsustainable, public anticipation of currency appreciation triggers inflows of international capital and pushes the prices of stocks and real estate even further up. Calvo et al. (1996) studied the data spanning 1990 to 1994 of Asian and Latin American countries and the results of their study showed that the inflow of international capital not only causes stock and real estate prices to rise but also result in rapid growth in foreign exchange reserves and money supply, along with appreciation of real exchange rates.

Kim and Singal (2000) estimated changes in the level and volatility of stock returns, inflation and exchange rates around market openings, and found that the movements of speculative funds, particularly in emerging markets, are apparently highly sensitive to differences in interest rates, expectations of currency revaluations and expected returns from holding of securities. Benson et al. (1997) examined the influence of buying and selling by Canadians in a study of 397 residential properties

[4] Examples include the burst of the Japanese asset price bubble in the 1990s and the collapse of the housing market in Thailand in 1997.

in Point Roberts, Washington. They found that the sensitivity of real estate prices to exchange rate changes appears to be a three-to-six month lagged function. In general, it appears that a higher Canadian dollar increases the Canadian demand for Point Roberts real estate which, in turn, leads to higher transaction prices.

Benson et al. (1999) used autoregressive moving average (ARMA) for tracking the data from Bellingham's housing market for the period between 1984 and 1994. The analysis suggested that a 10% rise in the exchange rate leads to a 7.7% rise in Bellingham home prices and concluded that the exchange rate has positive and significant impact on house prices.

Based on the experience of various nations, one can identify a positive relationship between the appreciation of currency and real estate prices. In recent years, due to the growing expectation of appreciation of the RMB, substantial international capital has entered China through various channels to engage in short-term speculative investments through the acquisition of RMB assets in order to benefit from both the appreciation of the RMB and the rise in value of domestic assets. Chu and Sing (2004) believed that the growth of real estate prices in China is largely because of a large influx of foreign capital into the market.

IMF (2007) maintained that under the circumstance of continued massive capital inflow, quickly rising costs can render sterilized intervention policies ineffective in preventing the appreciation of the domestic currency. In recent years, the rising costs of sterilized intervention in China has made such policies unsustainable and created asset pricing bubbles. The inflow of foreign speculative capital not only stimulates inflation, but also further accelerates the rise of stock prices and real estate market bubbles (Zhang and Fung, 2006). Guo and Huang (2010) utilized a multivariate VAR model with Markov regime-switching (MS) feature. Results of empirical analyses revealed that speculative capital inflows had aggravated short-term property prices and enhanced volatilities in both real estate and stock markets in China.

Short-term international capital inflows have not only caused domestic housing prices to go up but also escalated the fluctuation of housing prices in China. With RMB appreciation expectation, foreign investors have entered the Chinese market through various channels. Since the channels of investment are simple in China, all foreign investments ultimately converge in the real estate market, which is known for asset value preservation and appreciation. Liu and Wray (2010) analyzed two contending views of money and excess liquidity at both the theoretical and the practical levels. They related the analysis to China's skyrocketing credit expansion in 2009 and its relationship with the housing market boom. The conventional view is that such a bubble is highly dangerous and is largely caused by excess liquidity, which, in turn, induced Chinese banks to lend funds. This supposedly fueled the fire in real

estate markets and also pushed up the stock market.

Real estate prices in China and investment-oriented real estate demands have grown steadily in the past few years and as a result, bubbles have gradually formed in the housing market. Real estate is a crucial asset, the development and sales of real estate are both closely tied to financial support. With China's economy being so highly dependent on the nation's real estate market, if the government fails to exercise appropriate control over international investment and speculative capital movement, the development of China's real estate market may face daunting challenges.

The VAR model and the vector error correction model (VECM) have been widely employed in the current literature to investigate the effects of foreign capital on domestic asset prices, with an analytical emphasis on the impacts of short-term foreign capital inflow on real estate and stock markets. Despite the ignorance of the interactions among variables, these studies did not delve into the impacts of unsterilized portion of the monetary base on the domestic capital market.[5] Accordingly, the present study uses a SVAR model and includes a variable for the unsterilized portion of the monetary base. In addition to exploring the effects of short-term foreign capital inflows and the unsterilized portion of the monetary base on asset prices in China, the extent to which rises in asset prices further attract short-term inflows of foreign capital is analyzed. These serve as references to maintaining financial stability in China.

3.3 An Overview of Short-term International Capital Inflows and Asset markets in China

Short-term international capital comprises short-term speculative funds that rapidly move between different countries in the world financial markets to pursue the highest interest rates and opportunities for getting maximum profits. A large-scale influx sharply raises asset prices of individual economies when speculative funds come in, fueling speculative bubbles and severely affecting the economic and financial system. In the context of appreciation of RMB being expected in recent years, large amounts of hot money have poured into China from every channel, purchasing properties and stocks and engaging in short-term speculation in order to obtain dual profits of rising Chinese asset prices and appreciation of RMB.

As short-term international capital has strong influence on China's economy through the effect of money multiplier, large capital flight can have an immeasurable impact on China's economic and financial stability. Accordingly, thorough

[5] The unsterilized portion of the monetary base is defined as the current funds outstanding for foreign exchange minus the net value of the current issuance of central bank bills and the net value of the reserve requirements.

understanding of short-term international capital movements and effects of short-term international capital on real estate and stock markets, along with measurements of and control over international short-term capital, is of great significance for maintaining stability in the macro economy and preventing financial crises. The following figures and data are used to explicate the status of real estate and stock markets and the recent movements of short-term international capital in China, and to explore possible impacts of international short-term capital on Chinese real estate markets and stock markets.

Since short-term international capital is by nature highly speculative, highly liquid and highly diversified, measuring its size becomes difficult. There has been no consensus on methods of measurement. For short-term international capital, two measurement methods have been employed in the literature. First, net errors and omissions in the balance of payments are used to estimate the size of short-term international capital inflows. Since net errors and omissions are used for balancing the balance of payment, they do not bear any real economic meaning. We thus employ the second method; we define short-term international capital as changes of foreign exchange reserves minus trade surplus and foreign direct investment (Zhang and Fung, 2006).

Table 3.1 shows that despite a slight decline in the amount of short-term international capital flowing into China in 2008 due to influences of global financial crisis, it has risen steadily since 2005, reaching to 342,749.67 million USD in 2009. Afterwards, though it gradually decreased with time, showing a negative level in 2012, the impacts of short-term international capital on the domestic assets market are still substantial.

Figure 3.1 shows that Shanghai's stock composite index declined for four years since 2000, a downfall of as much as half of the level in 2000. It began to rise substantially since 2005, reaching a record high of 4,300 on average in 2007. Then it began to dip continuously, reaching a record low of 2,200 in 2012, a drop of as much as 48.84%. The housing price at the same time showed slight upward fluctuations, increasing up to 1.77 times 2012 as compared to 2000, indicating that the Chinese real estate market was booming in that year.

China's economic growth has remained strong in recent years, with growth rates of up to 10% being recorded from 2003 until 2007. After the global financial crisis in 2007, China's economic growth slightly slowed to 9.6% in 2008 and once reached a record low of 9.3% in 2011, its second lowest rate of growth for nine years. However, in the context of global financial crisis, other major economies such as the United States and the European Union are almost in recession; global economic growth rates

during the same period of time were only 3.7% and 4%. The Chinese market, comparatively speaking, is still a relatively active investment target.[6]

Table 3.1: Short-term International Capital Inflows in China ── 2000 to 2012

Unit: million USD

	Changes in Foreign Exchange Reserves (1)	Trade Balance (2)	Foreign Direct Investment (3)	Short-term International Capital Inflows (4) = (1) – (2) – (3)
2000	10,899	2,009.08	40,772.00	-31,882.08
2001	46,591	1,878.83	46,878.00	-2,165.83
2002	74,242	2,534.08	52,743.00	18,964.92
2003	116,844	2,122.42	53,505.00	61,216.58
2004	206,681	2,674.83	60,630.00	143,376.17
2005	208,940	8,500.00	72,406.00	128,034.00
2006	247,428	14,789.58	72,715.00	159,923.42
2007	461,949	21,890.42	83,521.00	356,537.58
2008	417,781	24,843.92	108,312.44	284,624.64
2009	453,122	16,307.33	94,065.00	342,749.67
2010	448,186	15,125.42	105,735.24	327,325.34
2011	333,810	12,908.17	116,009.85	204,891.98
2012	130,441	19,204.33	111,716.14	-479.47

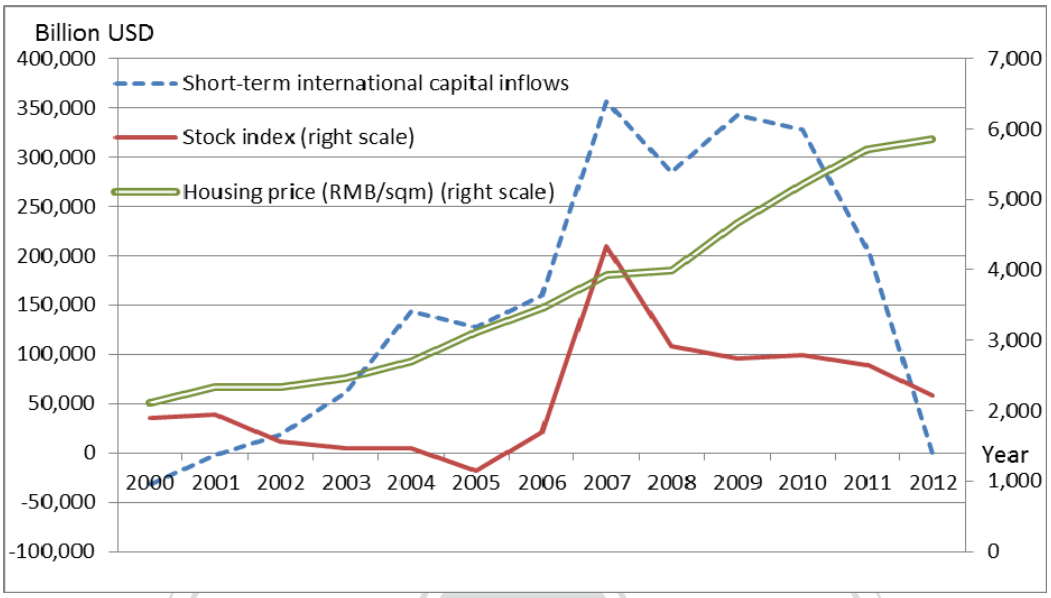
Note: This method we employ cannot exclude trade finance and capital movement among commercial banks, thus causing the overestimation of short-term international capital inflows.

Source: Same as Figure 2.3.

As China's economy is still growing steadily, even after the global financial crisis, short-term international capital targets Chinese real estate markets and stock markets since they have more arbitrage opportunities. Attracted by the expected appreciation of RMB and high profits in the asset market, continuous influx of short-term international capital contributes to unceasing increases in housing prices and volatility of stock prices. As shown in the figure, the amount of short-term international capital inflows fluctuated heavily since 2003, soaring from 2006 until 2007. Though it slightly declined due to the global financial crisis in 2008, it still amounted to a high level of USD 284.62 billion. At the background of the transformation of RMB appreciation expectation, the slowing down of China's economic development, and the European debt crisis since the second half of the year 2011, the tendency that a large scale of foreign capital flowing into China since 2005 has been transformed. The continuous "double favorable balance" between the current

[6] See International Monetary Fund, *World Economic Outlook*.

account and the capital-financial account presented a downward trend, reducing the size of international speculative capital inflows into China (Figure3.1).



Source: Same as Figure 2.3.

Figure 3.1: Housing price, Stock Price and Short-term International Capital Inflows

As long as appreciation of RMB is expected in the market, the economy continues to grow, and asset prices keep going up, short-term international capital will continue to flow into China. The central bank keeps absorbing excess foreign exchange by putting the surplus in foreign exchange reserves, in order to stabilize the exchange rates. This not only severely constrains the independence of the Chinese monetary policy but also accelerates pressure on inflation, resulting in negative impacts on the efficiency of macroeconomic adjustment.

3.4 Empirical Model

Integration of global economy has promoted the integration of capital markets, providing a variety of channels for international capital flowing across countries. The proportion of international capital having the highest mobility is called short-term international capital. It originates from large scale movements of capital away from economies with fixed exchange rate systems as investors make short-term cross-market investments based on the assumptions of expected appreciation of currencies and international interest rate arbitrages being higher than exchange rate risks.

Short-term international capital inflows and the unsterilized portion of the monetary base may have impacts on Chinese asset markets. In order to examine the effect of foreign capital on the domestic asset markets in China, we adopted a SVAR model to examine the impact of unsterilized portion of the monetary base and international capital on China's stock and real estate markets. In its basic form, we let y_t denote an $(k \times 1)$ vector of random variables and follow a p^{th} order VAR. The VAR(p) process is then defined as:

$$y_t = A_1 y_{t-1} + A_2 y_{t-2} + \cdots + A_p y_{t-p} + \varepsilon_t, \; t = 1, 2, \ldots, T, \tag{1}$$

simplifying Equation (1) obtains:

$$A(L) y_t = \varepsilon_t, \; t = 1, 2, \ldots, T, \tag{2}$$

where $A(L) = I - A_1 L - A_2 L^2 - \cdots - A_p L^p$, ε_t is k dimensional vector of structural innovations process with $\varepsilon_t \sim N(0, \Sigma)$. If VAR(p)-process is stable, rewriting Equation (2) gives:

$$y_t = B(L) \varepsilon_t, \; t = 1, 2, \ldots, T, \tag{3}$$

where $B(L) = A(L)^{-1} = B_0 + B_1 L + B_2 L^2 + \cdots$, and B_0 denote an $(k \times k)$ identity matrix.

Given that the foregoing VAR model does not specify contemporaneous relationships among variables, in order to tease out these relationships from matrix Σ, we need to convert Equation (1) into a SVAR model of order p as follows:

$$\Gamma_0 y_t = \Gamma_1 y_{t-1} + \Gamma_2 y_{t-2} + \cdots + \Gamma_p y_{t-p} + u_t, \; t = 1, 2, \ldots, T, \tag{4}$$

where Γ_0 denote an $k \times k$ matrix with all diagonal elements being 1, which reflects contemporaneous relationships among variables. u_t is k dimensional vector of error term with $E(u_t u_t') = I_k$. Simplifying Equation (4) obtains:

$$C(L) y_t = u_t, \; t = 1, 2, \ldots, T, \tag{5}$$

where $C(L) = \Gamma_0 - \Gamma_1 L - \Gamma_2 L^2 - \cdots - \Gamma_p L^p$. If we can find the inverse matrix of $C(L)$, rewriting Equation (5) gives:

$$y_t = D(L) u_t, \; t = 1, 2, \ldots, T, \tag{6}$$

where $D(L) = C(L)^{-1} = D_0 + D_1 L + D_2 L^2 + \cdots$ and $D_0 = C_0^{-1}$.

Comparing Equations (3) and (6) derives a typical SVAR model:

$$B(L) \varepsilon_t = D(L) u_t, \; t = 1, 2, \ldots, T, \tag{7}$$

let $B_0 = I_4$ and Equation (7), we obtain $\varepsilon_t = D_0 u_t$.

Given the present study employs a SVAR model of order p and four variables,

six constraints are imposed on the structural form.[7] While asset price fluctuations may interact among different assets due to investors' expectations, it is not easy to quickly sell off properties in real estate market as compared to selling shares in stock markets. We thus assume that the ratio of deviation of housing price from its trend (H) affects the ratio of deviation of stock price from its trend (S) but S does not have any influence on H over the same period. We also assume that S and H do not affect the growth rate of unsterilized portion of the monetary base (M) and the growth rate of short-term international inflows (K), and K is not affected by the contemporaneous M. Based on the above analysis, if we specify $y_t = (H, K, M, S)$, the contemporaneous coefficient matrix can be expressed in the following form:

$$D_0 = \begin{bmatrix} 1 & d_1 & d_2 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & d_3 & 1 & 0 \\ d_4 & d_5 & d_6 & 1 \end{bmatrix}.$$

Despite deriving the contemporaneous parameter matrix, the present study also uses impulse response functions in SVAR models to explore the impact of one standard deviation positive shock in a given variable on other variables in the system. It further analyzes the relationships among short-term international capital inflows, unsterilized portion of the monetary base, and asset prices.

3.5 Data and Empirical Results

In this section, selected sample variables are subjected to the unit root test, to find out the relationships among growth rate of unsterilized portion of the monetary base (M), growth rate of short-term international capital inflows (K), ratio of deviation of housing price from its trend (H), and ratio of deviation of stock price from its trend (S) in China. After confirming the relationships among these variables, impulse response functions are applied to explore the associations among M, K, H, and S. The effect of foreign debt on development of the financial sector and economic growth is also assessed. The extent to which rises in the asset prices attract short-term inflows of foreign capital is also assessed.

3.5.1 Data Description and Unit Root Tests

Real estate markets and stock markets in China are main investment channels for

[7] Suppose the VAR and SVAR models of order p and four variables, the number of parameters to be estimated from Equations (1) and (4) are $k^2p+[(k+k^2)/2]$ and k^2p+k^2. Accordingly, the number of constraints to be imposed are $(k^2p+k^2)-\{k^2p+[(k+k^2)/2]\}=[k(k-1)]/2$.

foreign capital. In addition to short-term international capital inflows, unsterilized portion of the monetary base may also impact the domestic asset market. The present study therefore conducts empirical analyses of these four variables, growth rate of unsterilized portion of the monetary base (M),[8] growth rate of short-term international capital inflows (K),[9] ratio of deviation of housing price from its trend (H),[10] and ratio of deviation of stock price from its trend (S). Besides, as the PBC started to publish the data on its reserve requirements since January 2006 and has not adopted issuance of central bank bills as a sterilization tool since December 2011, the data sample for the present empirical analysis is at monthly frequency. There are a total of 71 observations from February 2006 to December 2011. Table 3.2 summarizes the measurement and sources of the various data used in the estimating equations.

Table 3.2: Variables and Data Sources

Variable	Source
FOFEX: The current funds outstanding for foreign exchange	PBC
NICBB The net value of the current issuance of central bank bills	PBC
NRR The net value of the reserve requirements	PBC and TEJ database
$M:(\text{FOFEX})_t-(\text{NICBB})_t-(\text{NRR})_t$	--
$K:(\text{Change in foreign exchange rate})_t-(\text{Trade balance})_t-(\text{FDI})_t$	CEIC database
$H:\frac{(\text{Housing price})_t-(\text{Housing price trend})_t}{(\text{Housing price trend})_t}$	CEIC database
$S:\frac{(\text{Housing price})_t-(\text{Housing price trend})_t}{(\text{Housing price trend})_t}$	CEIC database

Before performing the estimations, unit root tests are conducted to examine the stationarity properties of the variables, and to ensure that incorrect inferences are not drawn due to spurious regressions. This study has adopted the Augmented Dickey-Fuller (ADF) method of Dickey and Fuller (1979) to test whether the time series is stationary. The results are listed in Table 3.3. The results of ADF unit root tests reveal that all variables are stationary at the 5% level of significance.

[8] In this study, the variable for the unsterilized portion of the monetary base is defined as the current funds outstanding for foreign exchange minus the net value of the current issuance of central bank bills and the net value of the reserve requirements. The net value of the current issuance of central bank bills is defined as the value of the current issuance of central bank bills minus the value of maturing central bank bills and plus the current interest payments. The net value of the reserve requirements is defined as the changes in the current deposits with the central bank minus its interest payments.

[9] We define short-term international capital as increases of foreign exchange reserves minus trade surplus and foreign direct investment (Zhang and Fung, 2006).

[10] $H_{c,t-1}$ is calculated as the ratio of housing price minus housing price trend against house price trend; S is calculated as the ratio of Shanghai Stock Composite Index in Shanghai Stock Exchange minus Shanghai Stock Composite Index trend against Shanghai Stock Composite Index trend. Hodrick-Prescott (HP) filter method is used to extract the trend of each variable in our study.

Table 3.3: Unit Root Test for Short-term International Capital Inflows

Variable	τ Statistic
H	-4.66***
K	-8.38***
M	-8.44***
S	-1.94**

Note: ** and ***denote that the τ statistic is significant at 10% and 1% levels, respectively.

3.5.2 Empirical Results

Below is the contemporaneous coefficient matrix D_0 estimated through the use of a SVAR model. Based on the results from the matrix, among the six estimated coefficients only the contemporaneous effect of K on H is significantly different from zero. This indicates that when the growth rate of short-term international capital inflows rises by 1%, Chinese real estate market is contemporaneously affected and the ratio of deviation of housing price from its trend increases by 0.394%. Given the interdependent and intricate relationship between China's housing market and her financial sector, a crisis in the real estate market that may lead to liquidity risks in the banking sector can easily escalate into a full-blown financial crisis.[11]

$$D_0 = \begin{bmatrix} 1 & 0.394^{***} & -0.089 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & -0.040 & 1 & 0 \\ -0.034 & 0.048 & 0.059 & 1 \end{bmatrix}.$$

Note: ***denote that the z statistic is significant at the 1% levels.

Impulse response functions for SVAR model are shown in Figures 3.2 to 3.4. Dashed lines represent the intervals of two standard deviations, while the solid lines represent the impulse function. Figure 3.2 reveals that given the one standard deviation positive shock in K variable, the initial responses in H variable and S variable are statistically significant. This shock initially is strongly transmitted into H variable. The response of H variable to the shock in K has been positive, persisting

[11] The rest of the estimated coefficients are not statistically significant, meaning that there are no significant interactions among these contemporaneous variables. However, this does not mean that there are no lagged effects of one shock in a variable on another variable. Impulse response functions are therefore used to explore the effect of one positive shock to a given variable on the other variables. The relationship among short-term international capital inflows, unsterilized portion of the monetary base, and asset prices is further analyzed.

approximately for six months. The response of S variable to the shock in K is smaller in magnitude but more persistent, lasting approximately 16 months. In the beginning of the shock, H variable is around 1.66% above the trend level and S variable has risen 0.5%.

Figure 3.3 shows the responses to a positive shock in M variable. Given the one positive shock of one standard deviation in M variable, the response of H variable first declines by 0.376%, and soars thereafter to a maximum of 2.57% by the second month. The response of S variable to the shock first rises by 0.62%, reaching its maximum of 1.2% in the fourth month. In addition, the responses of H and S variables to the shock in M closely resemble Figure 3.2. Whether faced with a shock in K variable or M variable, the response of S variable is smaller in magnitude than that of H variable, and it is more persistent.

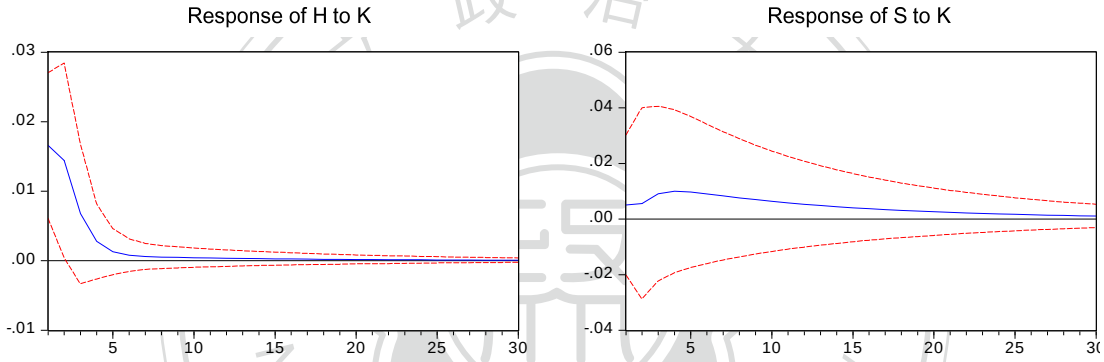


Figure 3.2: Impulse Response to One Standard Deviation Shock in K

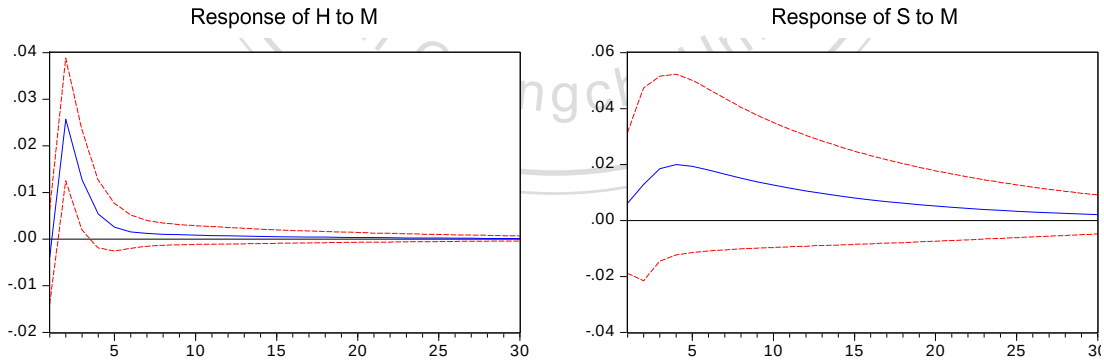


Figure 3.3: Impulse Response to One Standard Deviation Shock in M

The final parts to be examined are the responses of K variable to the one standard deviation positive shock in H variable and S variable. Figure 3.4 shows that as compared to the increase in stock prices, the surge in housing prices attracts larger inflows of short-term international capital. Given a positive shock of one standard deviation in H variable and S variable, the response of K variable rises, reaching its

maximum of 2.6 and 1.63 in the second and fourth months, respectively. Nevertheless, while the response of K variable to the shock in S is much smaller in magnitude than that in H, it persists and returns to a steady state in 18 months.

Investors' expectations of RMB appreciation and the rapid development in China's real estate markets have made the real estate sector the main investment target for foreign investors. In this context, a large influx of short-term international capital pours into China. Foreign investment flowing into the real estate sector not only exacerbates the imbalance between demand and supply in the market but also pumps up housing prices. This leads to intensified pressure on RMB appreciation and heightened expectations of sustained high profitability. Moreover, in order to avoid large fluctuations in exchange rates and deal with the resultant impacts from foreign capital due to expected RMB appreciation, the PBC continuously intervenes in the foreign exchange market. The released funds outstanding for foreign exchange also contribute to asset price bubbles.

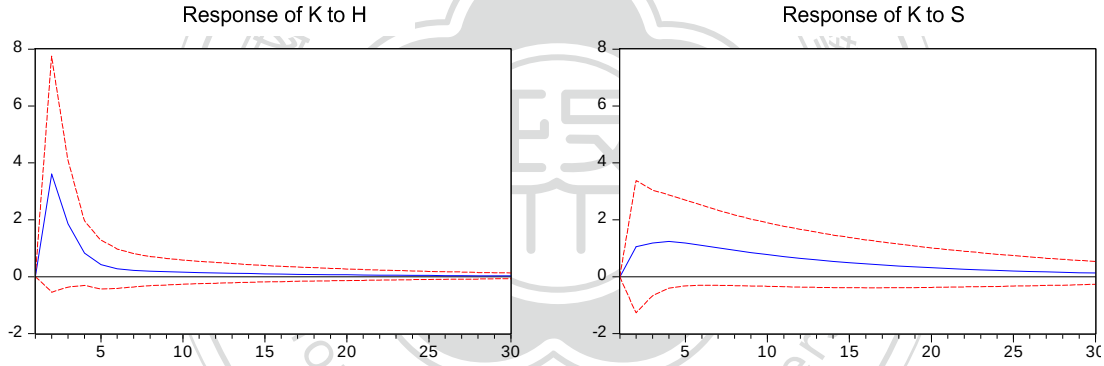


Figure 3.4: Impulse Response of K to One Standard Deviation Shock in H and S

Given the foregoing analysis, the relationship between short-term international capital inflows and asset prices is self-fufilling and mutually reinforcing. With the apprecation of both RMB and asset prices expected, short-term internaionl capital flows into China's asset markets. And the influx of short-term international capital not only leads to increases in foreign exchange reserves but alo induces expansion of domestic money supply and pushes up asset prices.[12]

While foreign capital inflows promote development in financial market and bring economic growth, there are also problems such as imbalance in balance of payments, appreciation pressure on RMB, and excess liquidity. With economic development shifting in different directions and higher degree of risks in national investment,

[12] Alothough the PBC intervenes in the foreign exchange market and at the same time actively adopts sterilized intervention, the PBC cannot sterilize all funds outstanding for foreign exchange. Therefore, short-term internatioanl capital inflows increase to a certain degree the domestic money supply.

massive international capital inflows can not only result in financial crises in China but also exacerbate risks of asset price bubbles. It not only impedes steady development in asset markets but also severely impacts the economic system.

3.6 Summary

In the context of heightening expectations of RMB appreciation, inflows of short-term international capital for speculative purposes are considered to be an important factor contributing to the formation of housing price bubbles and stock price volatility. Besides, the central bank opts for converting the external pressure for RMB appreciation to the internal momentum for monetary expansion. This has aggravated the problem of excess liquidity in the asset market. In the context of rising foreign exchange reserves and monetary authorities being unable to sterilize all funds outstanding for foreign exchange due to foreign exchange market interventions, increases in asset prices have gradually made people question the interaction between short-term capital inflows and asset prices that contributes to asset price bubbles.

The present study employs a SVAR model to analyze the relationships among the unsterilized portion of the monetary base, short-term international capital inflows, and asset prices. The empirical evidence demonstrates that the relationship between short-term international capital inflows and asset prices is self-fufilling and mutually reinforcing. The unsterilized portion of the monetary base further exacerbates asset price bubbles.

As speculation in the real estate and stock markts exerts negative impacts on the transformation of Chinese economy, heightened asset price volatility leads to strong expectations of inflation or deflation in the future macroeconomic environment, which threatens financial stability. In order to maintain steady economic growth and development, the Chinese government should focus on policy coordination. Despite adopting a flexible foreign exchange rate system, the authority shall foster a well-rounded financial market to formulate a more reasonable interest rate policy, provide a better environment for the RMB exchange rate reform, and adopt strict controls over credit loans for speculative investment in asset markets. All of these will effectively prevent the domestic financial system from being severely impacted by asset price bubbles due to short-term international capital inflows, and further maintain normal functioning of financial markets and sustainable economic development.

Chapter 4
The Estimation of Housing Price Bubbles in China

4.1 Introduction

Since it began economic reforms in 1979, China has witnessed incredible economic growth, with annual growth rates sustained at no less than 8% for significant periods of time. China's economy (until recently) may be described as a high savings, low consumption and export oriented economy. The global financial crisis that devastated the world in September 2008 prompted China to change its export-driven strategies for economic growth in favor of expansionary fiscal policy to increase domestic demand and to encourage private consumption. In addition to boosting domestic demand and consumption, the Chinese government has implemented policies with the underlying premise that "growth is dependent on investment, which is in turn dependent on the government." However, there has been substantial expansion of credit and loans to real estate developers and speculators, which has pushed prices of real estate, including housing, to very high levels, leading to a stage where the boom is being viewed as a bubble.

In recent years, China's real estate market has sustained rapid growth. Since 2000, the growth in real estate investment in China has been steady at not less than 20%. Real estate market growth has never been lower than growth of total investment in fixed assets. In 2005 when growth of real estate fell below the growth of total investment in fixed assets because of implementation of various macro-economic adjustment policies. In 2009, the growth in real estate investment dipped as low as 16.1%. However, the series of fiscal stimulus programs that the Chinese government implemented as countermeasures to the global financial crisis in 2008 resulted in growth rate in real estate investment once again soaring to 28.1% by the end of 2012; this was far in excess of the 12% growth in the nation's total fixed asset investment. Not only that, housing investment to GDP ratio in China has also steadily risen over the years; by the end of 2011, it was as high as 13.1%. This is an obvious sign of the rapid development that the Chinese housing market has undergone.[1] However, the excessive investment in China's housing market has also resulted in the general rise in housing prices across the nation, leading to an imbalance in total average rate of profit.[2]

In order to suppress speculation and prevent formation of bubbles in the housing

[1] See National Bureau of Statistics of China, *China Statistics Annual Report*.

[2] Average rate of profit refers to the annual rate of profit generated by the total social capital; it is also known as "general rate of profit". It represents the ratio of surplus value against total social capital.

market, the People's Bank of China has raised the down payment ratio and interest rates applicable to loans for second and subsequent properties bought by a person.[3] In addition, the Chinese government has also implemented a series of measures to combat property speculation. These include policies that restrict foreign investment in real estate, regulation of residential housing demand created by excessive property demolition during the process of urban renewal by district governments, raising taxes on sale of existing properties, enforcement of mandatory payment of business tax in full for properties sold within two years of purchase by individuals and so forth. These measures not only limit the profits of housing investments but also help suppress demand and prompt prospective investors in real estate to re-evaluate their anticipations of future rise of housing prices. The psychological impact of these measures on investor behavior has outweighed its actual impact, dissuading investors from jumping blindly on the bandwagon, thereby effectively retarding the formation of real estate bubbles.[4]

It is important to realize that China's housing market has always remained highly dependent on credit from the nation's banking industry. From 2001 onward, the growth in credit to real estate has always remained at 25% and higher. In 2009, aggregate outstanding loans for real estate development (from major financial institutions, rural cooperative financial institutions and urban credit cooperatives) were 3,000 billion RMB; this translates into a substantial growth of 10.7% compared to 2010. Aggregate individual housing loans also went up to 961 billion RMB, an increase of 13.5% compared to 2010.[5] On a related note, outstanding commercial real estate development loans during the period from 2004 to 2012 have always been about 13% to 20% of total outstanding loans in the economy. These figures adequately demonstrate the extent of the banking sector's support to China's housing market.

Expansion of credit has always been one of the leading causes of asset price inflation and burst of various bubbles in nations around the world. That said, as China's real estate market remains highly reliant on loans provided by the banking sector, it is only natural that significant amounts of risks have been steadily building up. Allen and Gale (2000) pointed out that agency problems in financial intermediation lead to formation of asset bubbles because there is a strong incentive

[3] The down payment ratio for loans on the first residential property over 90 square meters in area by a household must be no lower than 30%; the down payment ratio for loans on the second residential property purchased by a household must be no lower than 50%, with loan interest rate no lower than 110% of the benchmark interest rate. The down payment ratio and interest rates for loans on the third and subsequent residential property purchased by a household would be dramatically increased.

[4] The empirical results of this paper reveal that despite the resolve the Chinese government has shown to restore order to the nation's real estate market, the policies are yet to produce significant results.

[5] See People's Bank of China, *Statistical Reports in Invest Directions of Loans from Financial Institution*.

for personnel involved in financial intermediation to approve loans unchecked due to personal interests, which results in speculation. Herring and Wachter (2003) also noted that loans from banks play a significant role in formation of housing bubbles primarily because the rise in housing prices directly increases the value of real estate collateral, thereby driving banks to offer more real estate loans. In addition, during periods of a real estate boom, due to the increasing competition from banks with narrow risk framing, prudent banking institutions also follow the trend by adopting more lenient loan standards in order to maintain their market shares. These two specific factors are directly responsible for expansion of banks' credit loans and worsening of real estate bubbles. Given the interdependent and intricate relationship between China's housing market and her financial sector, a crisis in the real estate market that may lead to liquidity risks in the banking sector can easily escalate into a full-blown financial crisis. As such, acquiring sufficient understanding of China's real estate market for an accurate assessment of the risk of a housing price bubble has become an issue that requires immediate attention.

The existence of speculative bubbles in real estate market has always been a highly debated issue in many circles. Economists believe that under the premise of rational expectation, value of assets should be determined by market fundamentals. When the price of a specific asset has deviated from market fundamentals, it would usually be perceived as unreasonable and irrational, and such deviation is known as a "bubble".[6] Theoretically speaking, both "price to rent ratio" and "price to income ratio" serve as key indicators of development of real estate bubbles. However, most of previous literature have focused on analyses from the perspective of rent or income, the authors propose that the fundamental pricing of housing market should be equivalent to the present value of real estate rent earnings. Per se, extant literature has chosen to discuss the issue of real estate bubbles using the price to rent ratio. However, one must also consider the fact that the signing of rental contracts leads to temporary rigidity of rent pricing and as time passes, factors such as the time of contract signing and discrepancies in contract terms might also cause fluctuations in rentals, which are mitigated over the long run. In other words, the use of price to rent ratio for analysis of real estate bubbles can result in overestimation (when the economy is booming) or underestimation (during a recession) of rational prices.

Household income is not merely a representation of real estate buyers' capacity to afford housing purchases; it is also intricately connected to housing prices.[7] That is

[6] The occurrence of bubble economy is caused by a variance in intrinsic values due to speculation. Meese (1986), Woo (1987), West (1987) and Wu (1995) pointed out that bubbles can be represented as the discrepancy between asset prices and market fundamentals.

[7] Many literature have proven the correlation between housing prices and income using empirical models. Notable ones include Chen and Patel (1998), who used a vector error-correction model to analyze the correlations among prices of newly constructed houses in Taipei, household incomes,

why when growth of household income falls out of synchronization with growth in housing prices, it naturally follows that the general public would resort to various loans and financing options available in order to afford real estate. If housing prices were purely driven by investors' own funds, burst of the bubbles would not result in cross-sector impact. However, when real estate bubbles are created due to expansion of credit loans, it could easily escalate into a full-scale financial crisis, causing liquidity risks in the financial sector. In order to create a model that is better suited for the study of real estate bubbles, price to income ratio is chosen as the indicator for measurement of housing prices in this study.

After introduction, the second section of this paper presents a quick overview of relevant research works and literature on real estate bubbles, the third section provides a concise summary of the status of China's real estate market in recent years by looking at several indicators and assessment of China's real estate market, the fourth section is a short introduction to China's various real estate policies to present the evolution of the relevant policies in recent years. The fifth section focuses on empirical model, and the sixth section will cover the data and empirical results, followed by conclusions of this paper.

4.2 Literature Review

Flood and Garber (1980) were among the earliest scholars to apply bubble theories in empirical testing. They conducted bubble tests for the period of hyperinflation that Germany went through from 1918 to 1923. Their empirical findings indicated that there had been no price bubbles during the period of hyperinflation in Germany. However, Flood and Garber's methods were only applicable to assessment of deterministic bubble,[8] not for assessment of real estate bubbles. Flood and Hodrick (1990) proposed that a part of asset prices fluctuations is susceptible to influence of self-fulfilling factors. However, changes in prices caused by non-fundamental factors are often difficult to represent in capitalized pricing and could result in inconsistency between capitalized pricing and market prices. It is generally believed that given the premise of rational expectations, actual asset prices ought to adhere to prices predicted by market fundamentals, and when actual prices

short-term interest rates, stock prices and so forth and their results suggested that long-term equilibrium correlation exists between housing prices and these variables. Jud and Winkler (2002) also pointed out that housing prices in the United States were in fact susceptible to influences of income levels, interest rates, cost of building construction and population growth rate.

[8] Blanchard and Watson (1982) adopted the concept of rational bubbles and further separated it into deterministic bubbles and stochastic bubbles. The former refers to bubbles that would grow exponentially as time passes and never burst, while the possibility of the existence of the latter bursting may vary depending on factors such as lifespan of the bubble, the extent of deviation from market fundamentals and so forth.

deviate from market fundamentals, the discrepancy constitutes a bubble.

There have been a number of empirical studies in the past that focused on identification of real estate bubbles. Björklund and Söderberg (1999) used Gross Income Multiplier (GIM) in their study as a means to track the gap between asset prices and market fundamentals by examining data from Sweden's housing market for the period between 1985 and 1994.[9] They found that the ratio of housing prices to rental income was too high and concluded that a bubble did in fact exist. Kim and Suh (1993) carried out their study based on data collected in Korea and Japan and their empirical findings revealed that a growing rationale bubble existed in Korea from 1974 to 1989. Kim and Lee (2000) used cointegration tests as the principal tool and identified bubbles in Korea's housing prices.[10] Bourassa et al. (2001) selected a number of suitable variables from market demand and supply for estimation of fundamental prices and defined the error term as bubble prices in their study on three major cities in New Zealand (Auckland, Wellington and Christchurch). They then compared their empirical findings with empirical results from other literature, including 22 Swedish cities that Hort examined in his 1998 work, and found a high degree of similarity between the results they had gathered in New Zealand and the results that Hort had obtained in Sweden. Both studies suggested a modest price bubble potential.

Beginning from the 1980s, the Chinese government commenced implementation of housing commercialization policies and officially established a trading market for real estate in 1998. From then on, real estate transaction prices have been on a steady rise. Deng et al. (2009) pointed out that during the period between 2001 and 2004, average growth of housing prices in major cities across China had exceeded 25%. Not only that, housing prices in China continued to demonstrate rapid growth from 2004 to 2007. The series of fiscal stimulus policies launched by the Chinese government in an effort to mitigate the impact of the global financial crisis in 2008 only helped accelerate the rise in housing prices (Cova et al., 2010). Although the steeply rising housing prices in China are a sign of potential market overheating, studies on potential real estate bubbles have been limited at best.

Nevertheless, there are still a few studies have focussed on China's housing price bubbles. Shen et al. (2005) examined the Beijing and Shanghai housing markets using a Granger causality test and generalized impulse response analysis. They tested the house price bubble hypothesis in Beijing and Shanghai by comparing market house

[9] A real estate property's Gross Income Multiplier (GIM) is the ratio of real estate's sale price to real estate's annual gross rental income at the time of sale.

[10] Campbell and Shiller (1987) developed a set of methods to test present value models in their study. It involves the use of cointegration characteristics when the first-order difference of asset prices and future returns become stationary to determine the existence of a bubble.

price with the underlying economic fundamental based house price, finding a house bubble in Shanghai. Hui and Yue (2006) used a macro-econometric model to determine if housing price bubbles existed in Beijing and Shanghai in 2003. Their empirical results showed that while there was no housing bubble in Beijing at that time, the proportion of price bubble to house price in Shanghai was about 22%.

Christian and Zhang (2010) took an extensive set of data collected from 35 major cities in China between the period from 1998 to 2009 and applied a panel model along with cointegration techniques in their empirical study. They found that the bubble was about 25% of the equilibrium value implied by the fundamentals at the end of 2009, and the bubble was particularly huge in cities in southeast coastal areas and special economic zones. Ren et al. (2012) apply the theory of rational expectation bubbles to the Chinese housing market. Based on data from 35 cities in China, they have found no evidence to support the existence of speculative price bubbles in the Chinese housing market. Chen et al. (2013) investigated whether a bubble existed in the Beijing housing market from 1998 to 2010, using economic fundamental variables such as interest rates, inflation, and cost of supply. Results of the analysis revealed that the Beijing house price index was significantly larger than the equilibrium value, based on the relative economic fundamental variables during 2004 to 2007. Table 4.1 summarizes the various estimations about China's housing price bubbles.

Judging from the aforementioned, it would seem that the issue of real estate bubbles in China is not as serious as is believed. However, all empirical methods featured in these studies have adopted macro-econometric models which are not designed to validate the fact that a few selected macroeconomic variables can suitably represent the fundamental elements that influence housing prices, not to mention that omission of key macroeconomic variables would lead to bias in estimation of bubbles. Given these considerations, this paper adopts a different empirical approach to discuss the existence of real estate bubbles in China.

It is worthy to note that the deviation of asset prices from market fundamentals is a variable that cannot be observed. Previous studies that have performed integrated tests for housing prices and market fundamentals mainly focused on validation of bubbles by examining the stability of factors that were assessed. However, such an approach reveals only the extent of price stability, offering little insight into the extent of discrepancy between price bubbles and fundamental values. Not only that, the method of testing for economic bubbles using cointegration tests would no longer be suitable if the markets were to go through structural changes. On the other hand, in studies that used regression analyses to investigate the gap between actual prices and market fundamentals suffered the drawback of variables' omissions, which lead to improper model configuration and ultimately inaccuracy in bubble estimation.

Therefore, a state space model has been chosen in this research to determine if asset prices have in fact deviated from market fundamentals in China's real estate market.

Table 4.1: The Studies of Housing Price Bubbles in China

Literature	Method	Metropolitan areas (Time period)	Existence of bubbles
Shen et al. (2005)	A Granger causality test and generalized impulse response analysis	Beijing and Shanghai (January 1997 to December 2003)	NO (Beijing) YES (Shanghai[22%])
Hui and Yue (2006)	A macro-econometric model	Beijing and Shanghai (From 1990 to 2003)	NO (Beijing) YES (Shanghai [22%])
Hou (2009)	An integrated strategy involved with such fundamentals as interest rates, rent, income and GDP	Beijing and Shanghai (From 1995 to 2008)	YES Beijing (from 2005 to 2008) Shanghai (from 2003 to 2004)
Christian and Zhang (2010)	A panel model along with cointegration techniques	35 major cities in China (From 1998 to 2009)	YES [25%]
Ren et al. (2012)	Theory of rational expectation	35 cities in China (From 1998 to 2008)	NO
Chen et al. (2013)	Coleman et al.'s (2008) model based on the VECM	Beijing (From 1998 to 2010)	YES Beijing (2004 to 2007)

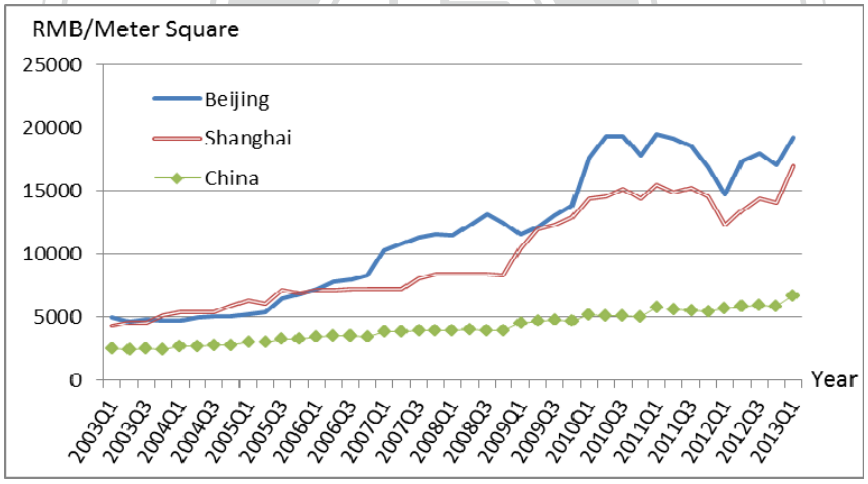
Note: [·] represent the proportion of price bubble to house price.

The state space model was originally devised to resolve the issue of the control theory in fields of engineering. However, it has also been extensively used in recent years in research on economics related subjects. Strengths of the state space model lie in the fact that it is not only capable of processing nonstationary time series but also allows the addition of variables that cannot be observed when analyzing economic phenomena. Variables that cannot be observed are generally known as state variables, and they include rational expectations, long-term income, measurement errors, circulatory factors and trends that cannot be observed and so forth. A linear state space model is usually composed of two equations: a state equation and a signal equation. The state equation is mainly used to represent the correlation between observable and unobservable variables, whereas the signal equation describes the trends of unobservable variables. Since real estate bubbles are an unobservable variable, a state space model has been chosen, in conjunction with recursive computation of the Kalman Filter, for estimation of the unobservable variable (bubble). The maximum likelihood estimation is used to avoid issues of inappropriate

model specification and address difficulties in predicting the extent of deviation between prices and market fundamentals that have been apparent in existing literature.

4.3 Status of China's Housing Market

The real estate market in China has witnessed explosive growth since the reforms began in the late 1980s. The whole of China's real estate market gradually became market oriented, with activities driven by effective demand. A quick look at housing prices in China in recent years reveals the fact that real estate prices in Shanghai, Beijing and China as a whole have shown notable upward trends (Figure 4.1). By the end of the first quarter of 2013, per square meter of housing price had reached 6,695.38, 19,243.22 and 16,928.04 RMB in China, Beijing and Shanghai as a whole, respectively. Compared to Q1 of 2003, these prices have increased by 166.68%, 290.91% and 293.47% for China, Beijing and Shanghai as a whole, respectively. The people of China have complained that the increase in housing prices has far exceeded what they could afford and skyrocketing real estate prices are telltale signs of risks and challenges of real estate bubbles in China.



Source: Calculated based on statistics published by CEIC Database.

Figure 4.1: Trend of Housing Prices in China, Shanghai and Beijing — 2003 Q1 to 2013 Q1

Given the highly heterogeneous nature of housing markets, factors leading to formation of bubbles too are highly complex. In theory, housing prices should be determined on the basis of return and utility. However, when prices get inflated abnormally and deviate drastically from actual values, bubbles are inevitable. Real estate prices are mainly driven by anticipation of future prices on part of consumers and real estate developers. Consumers tend to anticipate housing prices in the future

and their anticipation affects the demand in housing market. On the other hand, real estate developers' optimistic anticipation of housing prices in the future not only drives land prices up but also further elevates housing prices. In reality, the factor of anticipation affects housing prices through its impact on supply and demand in the real estate market. Thus, competent authorities have to pay more attention to management of anticipation, in order to keep housing prices under control. The following paragraph covers the changes of relevant indicators that are directly and indirectly related to investor anticipation, to discuss the extent and severity of real estate bubbles in China.

The Extent of Expansion of Bank Credit to Housing Sector

The ratio of housing market loans to total investment is a useful indicator that reflects the degree of dependence of the real estate market on the financial sector. Expansion of loans can be perceived as the increase in debt that consumers have to shoulder and diminishment of their capabilities to shoulder unforeseen risks. From Table 4.2, it is apparent that during the period 1999 to 2011, the ratio of loans made to real estate developers to the total amount of real estate investment over the years has always been about 15% to 24%. In order to comply with the increased threshold set for own funds by the Chinese government, real estate developers have been increasing their own funds over the years (from 134.46 billion RMB in 1999 to 3,500.46 billion RMB by 2011).

However, according to the *Report on the Analysis of Real Estate Funding Sources in China* published by the Statistical Analysis Taskforce of China Banking Regulatory Commission in September 2005, for many years, deployment of their own funds by real estate developers has been below the requirement stipulated by the government. Real estate developers have been resorting to various means to acquire loans from banks and declare the loans as their own funds. Though the data show that bank loans account for only about 15% to 24% of all funding, the fact is that bank loans remain a more important source of funding for real estate investments than what the data suggest. In recent years, the People's Bank of China and China Banking Regulatory Commission have adopted several financial policies related to funding of real estate development. As a result, real estate developers have had to deal with funding problems, resulting in higher interest costs which have indirectly caused housing prices to increase.

Table 4.2: Sources of Funding for Real Estate Developers

Unit: billion RMB

Year	Domestic Loans (1)	Foreign Funding (2)	Self-financing (3)	Other Funding (4)	Total (5)	Loan Ratio (%) (6)=(1)/(5)
1999	111.16	25.66	134.46	206.32	479.59	23.18
2000	138.51	16.87	161.42	281.93	599.76	23.09
2001	169.22	13.57	218.40	367.06	769.64	21.99
2002	222.03	15.72	273.85	461.99	975.00	22.77
2003	313.83	17.00	377.07	610.61	319.69	23.78
2004	315.84	22.82	520.76	856.26	1,716.88	18.40
2005	391.81	25.78	700.04	1,022.1	2,139.78	18.31
2006	535.70	40.02	859.71	1,278.1	2,713.56	19.74
2007	701.56	64.10	1,177.25	1,804.8	3,747.80	18.72
2008	760.57	72.82	1,531.21	1,597.3	3,961.94	19.20
2009	1,136.45	47.94	1,794.91	2,800.6	5,779.90	19.66
2010	1,256.37	79.07	2,663.72	3,295.2	7,294.40	17.22
2011	1,305.68	78.52	3,500.46	3,684.2	8,568.87	15.24

Source: National Bureau of Statistics of China, *China Statistics Annual Report*.

During the period from 2004 to 2012, loans extended by the banking sector have remained fairly concentrated in the real estate market. The ratio of loans extended for commercial real estate development to total loans declined marginally in 2008 (17.43%) and in 2012 (19.21%), but the figure has remained steady between 13% and 20%. Comparing with 2004, the ratio in 2009 has increased by 42.83%. These figures aptly reflect the strong support extended by China's banking industry to the domestic housing market.

Given the rapid growth experienced by the housing market in recent years, the banking industry has generally perceived real estate loans as quality assets and, therefore, has continued to provide loans to this sector. However, the financial sector seems to have inadvertently shouldered the risks of the real estate market even as it has earned high profits from lending to this sector. If the boom in the real estate market turn out to be a bubble, its burst may spark a crisis that may result in liquidity risks for the banking sector and possibly escalate into a full-blown financial crisis.

Table 4.3: Amount and Ratio of Loans Made to the Realty Business

Unit: billion RMB

Year	Total Loan Balance (1)	Balance of Commercial Real Estate Development Loans (2)	Ratio of Commercial Real Estate Development Loans to Total Loans Outstanding (%) (3) = (2)/(1)
2004	17,700	2,380	13.45
2005	19,500	2,770	14.21
2006	22,500	3,680	16.36
2007	26,200	4,800	18.32
2008	30,300	5,280	17.43
2009	40,000	7,330	18.33
2010	47,900	9,350	19.52
2011	54,800	10,730	19.58
2012	63,000	12,100	19.21

Note: Total outstanding loans are in RMB only and do not include loans in foreign currencies.

Source: People's Bank of China, *China Monetary Policy Report*.

Ratio of Real Estate Investment against Total Investment in Fixed Assets

With various reforms and rapid economic development in China, the general population in China has gradually accumulated wealth, leading to increased demand for investment opportunities. In recent years, substantial money has been injected into China's real estate market. According to data published by the National Bureau of Statistics of China, total real estate investment in China was merely 410.32 billion RMB in 1999, constituting 13.74% of the nation's total investment in fixed assets and 4.58% of China's GDP. However, in 2011, total of real estate investment had skyrocketed to 6,179.69 billion RMB, constituting as much as 20.20% of the nation's total investment in fixed assets and 12.47% of GDP. The spike in real estate investment clearly demonstrates the fact that the dependence of China's economy on the real estate market has reached a historic high (Table 4.4).

The pursuit of profit involved in investments cause investment funds to flow towards industries with higher profits. The constant growth and expansion of real estate development and the rising share of real estate investment in China's GDP reveal a distortion of the economy in terms of resource allocation. Although expansion of investment could facilitate economic development, the build-up and the subsequent bursting of real estate bubbles can severely threaten China's economic development in the future if the government fails to address it in time by giving it due attention.

Table 4.4: Investment of Fixed Assets and Real Estate Development in China

Unit: billion RMB

Year	Total Fixed Assets Investment	Total Investment in Real Estate Development	GDP	Real Estate Investment as % of GDP	Real Estate Investment as % of Total Investment in Fixed Assets
1999	2,985.47	410.32	8,967.71	4.58	13.74
2000	3,291.77	498.41	9,921.46	5.02	15.14
2001	3,721.35	634.41	10,965.52	5.79	17.05
2002	4,349.99	779.09	12,033.27	6.47	17.91
2003	5,556.66	1,015.38	13,582.28	7.48	18.27
2004	7,047.74	1,315.83	15,987.83	8.23	18.67
2005	8,877.36	1,590.92	18,493.74	8.60	17.92
2006	10,999.82	1,942.29	21,631.44	8.98	17.66
2007	13,732.39	2,528.88	26,581.03	9.51	18.42
2008	17,282.84	3,120.32	31,404.54	9.94	18.05
2009	22,459.88	3,624.18	34,090.28	10.63	16.14
2010	27,812.19	4,825.94	40,151.28	12.02	17.35
2011	31,148.51	6,179.69	47,288.16	13.07	19.84

Source: Same as Table 4.1.

Monthly Amortization Rate

The monthly amortization rate reflects the capacity of consumers buying real estate to repay loans.[11] Since the demand for real estate is highly dependent on consumers' ability to service the borrowings for house, the monthly amortization rate is an important indicator of sustainability of real estate prices (i.e. as a threshold for market overheating). If monthly amortization rate becomes too high, it means housing prices have grown far beyond what the consumers can afford and the risks of real estate bubbles would be relatively higher. After the first housing system reform meeting was convened in 1988, extension of credit loans for real estate had a head start in 1991 when both the China Construction Bank and the Industrial and Commercial Bank of China (ICBC) established their housing credit loan departments to offer individual housing credit loan services. Table 4.5 shows the monthly amortization rate based on various long-term loan interest rates announced by ICBC, assuming a 20% down payment and repayment period spanning 20 years.[12]

[11] Monthly amortization rate refers to monthly payment towards housing loans expressed as a percentage of a family's monthly income.

[12] Given the fact that the Ministry of Construction of China has stipulated that the area of well-off housing must be no less than 81 square meters, after calculating the amount of loans for each household, the ratio of monthly amortization rate against monthly household income can be derived from the amount of each installment, given the fixed interest rate and number of installments in Excel's PMT, as shown in Table 4.5.

Table 4.5: Monthly Amortization Rate for Family Housing Loans in China —— 2003 to 2012

Unit: %

	China	Beijing	Shanghai
2003	152.87	185.20	185.59
2004	160.24	175.29	194.69
2005	170.88	206.70	207.24
2006	156.05	227.62	224.98
2007	154.29	276.79	197.21
2008	135.22	260.85	175.72
2009	150.95	266.25	251.73
2010	143.86	316.81	250.17
2011	133.31	249.90	218.54
2012	128.88	232.54	192.39

Note: The Figures are calculated with the following premises: based on well-off house which are the area of no more than 81 square meters (as stipulated by the Ministry of Construction of China), with a 20% down payment and repayment spread over a period of 20 years.

Source: Same as Table 4.1.

According to standard international practices, the cap for monthly amortization rate is at 30% of a family's monthly income. The China Banking Regulatory Commission has stipulated that monthly amortization rate for real estate loans may not exceed 50% of a family's monthly income. Although the monthly amortization rate for real estate loans in Beijing, Shanghai and across China has declined gradually in the past few years, the value remains over 128%, far exceeding the percentage stipulated by the China Banking Regulatory Commission. In addition to reflecting the enormous pressure of repaying housing loans that common households have to shoulder, the statistics also reveal significant speculation in China's real estate market. Under this scenario, housing credit loans in China are in fact a source of incredible risks.

4.4 China's Real Estate and Housing Policies

The official launch of housing commoditization policies by the Chinese government in 1980 has made it legal for the general public to come into possession of private housing, thereby directly changing the nation's economic system and facilitating development of real estate construction. With various reforms and rapid economic development in China, the general population has gradually accumulated

wealth and funds injected into the real estate market have also risen by the day. In 1992, the number of real estate developers in China surged because of substantial increase in operational profits. Sales areas of properties have also grown at a steady pace, leading to vigorous growth in real estate market development. As a result, housing prices have gradually fallen out of the range that the general public can afford.

In order to stabilize prices in the housing market, the Chinese government had asked various branches and departments of the People's Bank of China in June 2003 to exercise stricter control over real estate credit loan policies and strengthen the management of real estate loans to minimize financial risks and facilitate healthy development of the real estate industry. In April 2004, the State Council further stipulated that real estate developers must raise the ratio of own funds to no less than 35% to prevent overheating of real estate investments. Starting from 2005, the Chinese government commenced implementation of a series of macro-economic policies.

On 26 March 2005, the State Council announced a concrete policy to stabilize housing prices as its primary objective.[13] On 30 April 2005, the State Council promulgated another new policy to accelerate the adjustment of China's housing markets by proposing a series of concrete measures.[14] However, housing prices in major cities such as Beijing, Tianjin, Guangzhou and so forth continued to rise even after the two aforementioned policies had been announced and implemented for over a year. Premier Wen Jiabao, therefore, convened an executive meeting on 17 May 2006 and proposed six measures aiming specifically at resolving the issues of rapidly rising housing prices across major cities,[15] unreasonable housing supply structure and

[13] Contents of the policy can be broken down into: (1) devoting more attention to stabilization of housing prices; (2) duly shouldering the responsibilities of stabilizing housing prices; (3) fully committing to adjustment and improvement of housing supply structure; (4) enforcing strict control of housing demand; (5) guiding the people to have reasonable consumption expectations; (6) implementing full-scale monitoring of operation of the real estate market; (7) taking an active stance in adjusting and regulating various housing supply and demand policies; and (8) adopting stricter standards in relevant supervision to stabilize housing prices.

[14] Contents of the policy can be broken down into: (1) strengthening planning and adjustments to improve housing supply structure; (2) exerting greater control over land supply and implementing stricter land control policies; (3) adjusting the policy on business tax for transfer of real estate ownership and enforcing stricter standards in tax collection; (4) fortifying real estate credit loan management to prevent financial risks; (5) clearly defining the incentives for regular housing standards to encourage reasonable real estate construction and consumption; (6) strengthening economic housing construction and creating an affordable housing rental system; (7) duly enforcing and restoring market order through strict investigation and prosecution of illegal acts of real estate sales; and (8) strengthening market monitoring and improving market information disclosure.

[15] Contents of the policy can be broken down into: (1) duly adjusting the structure of housing supply and demand; (2) further ensuring regulatory functions of policies on tax collection, credit loans and land regulation; (3) ensuring reasonable control of the scale and progress of urban housing demolitions to decelerate the growth of housing demand; (4) further adjusting and enforcing order in the housing market; (5) accelerating the establishment of housing rental system in cities and regulating the

chaos in the real estate market, to keep the overheating real estate market under control. Later on, the State Council drafted details of the six measures on 29 May 2006 with participation of the Ministry of Construction, National Development and Reform Commission, Ministry of Supervision, Ministry of Finance, Ministry of Land and Resources, People's Bank of China, State Administration of Taxation, National Bureau of Statistics and China Banking Regulatory Commission in the hope of regulating housing supplies through the new policies to stabilize housing prices.

Prior to 2005, the growth rate of real estate investment in China had remained high, even reaching up to 30.3% in 2003. In other words, policies implemented on May 17 and 29 in 2006 were designed within the background of expeditious growth in real estate investment. Perhaps it was the effect of these macro-economic policies that the speed at which real estate investment was growing gradually slowed from 2005 onward, and by the end of 2005, it had fallen to 20.9%. Since the growth of real estate investment had returned to a reasonable level, further manipulation and control of the housing market was considered undesirable as it might lead to severe impact on relevant industries. Given this consideration, conflicting opinions emerged from the responsible regulatory departments on the six measures announced by the Chinese government on 17 May 2006.

On one hand, the Chinese government was hoping to resolve the issues of the rapidly rising housing prices in major cities, unreasonable housing supply structure and chaos in the real estate market. On the other hand, it also emphasized the importance of the domestic real estate industry in the belief that continued and stabilized growth of real estate would facilitate stable economic growth for the nation. If China's real estate industry were to shrink, the nation's macro economy would no doubt be affected adversely. Perhaps it was such conflicting opinions among different segments of competent authorities that led to limited results of implementation of the aforementioned policies. Subsequently, the State Council once again announced two new policy measures on 14 December 2009 and 10 January 2010 that were aimed at promoting healthy development of the nation's real estate industry and pursuing its stability.[16] The Chinese government changed its previous stance of encouraging and promoting development of real estate industry, opting for a regulatory-policy driven

development of affordable housing construction; and (6) improving real estate statistics and information disclosure systems.

[16] The first policy involves four concrete measures, including suppression of unreasonable housing demand, increasing effective housing supply, accelerating construction of government-subsidized housing and strengthening of market supervision. The second policy covers five perspectives and involves 11 specific terms. The five perspectives include: (1) due fulfillment of responsibilities by district administrations and competent authorities in stabilizing housing prices and ensuring adequate supply; (2) staunch suppression of unreasonable housing demand; (3) increased effective housing supply; (4) accelerate construction of government-subsidized housing; and (5) strengthen market supervision.

stance in an attempt to demonstrate its resolve to fix the real estate market.

On 17 April 2010, the State Council took another step to launch a new policy to curb the accelerated rise in housing prices in specific cities by emphasizing that the issue of housing was more than just a problem of the nation's economy; it is a very real threat that can disrupt social security.[17] Fast rise in housing prices would not only be detrimental to the general population's welfare but also disadvantageous to coordination and development of the social economy due to greater financial risks. The core of the latest policy lies in deleveraging individual loans and real estate developers' financing in the hope of snubbing speculative attacks on the real estate market by driving up the costs of investors while changing the general public's expectations in the real estate market.

In September 2010, the government eliminated third mortgages and maintained minimum down payment for first mortgage at 30%. On 26 January 2011, "National Eight" regulations increase minimum down payment for second mortgages to 60%. Some cities, including Beijing, put new restrictions on home purchases by non-residents. Other tightening measures involving taxes and land transactions are enacted throughout the year. Besides, provident funds in some regions ease loan policies for first-time home buyers in 2012.

4.5 Empirical Model

A stable market environment facilitates a nation's economic growth and provides the pre-requisites for long-term development. However, based on analyses of statistics covered in the previous section, it should be apparent that speculation has been rampant in China's real estate market and the excessive monthly amortization rate also reveals a serious case of credit loan expansion. Considering excessive credit expansion can lead to liquidity risks in the financial sector and escalate into a full-blown financial crisis, adequate understanding of the real estate market has become an issue that requires immediate attention. This section focuses on the creation of an empirical model that features Kalman's Filter in a state space model, using the maximum likelihood estimation to determine if bubbles do exist in real estate markets of Beijing, Shanghai and China as a whole.

[17] Contents of the policy can be broken down into: (1) promote consensus and increase awareness; (2) establish evaluation and liability tracking systems; (3) enforce stricter differentiated housing credit loan policies; (4) ensuring regulatory functions of tax collection policy on housing consumption and real estate profits; (5) increasing effective supply of residential land; (6) adjusting housing supply structure; (7) ensuring completion of 3 million units of government-subsidized housing and reconstruction of 2.8 million units in shanty towns in 2010; (8) strengthening supervision of land acquisition and financing by real estate developers; (9) strengthening the extent of transaction order monitoring; and (10) improving market information disclosure systems.

In this study, the model presented by Black et al. (2006) is used to discuss the phenomenon of real estate price bubble. The model defines the correlation between housing prices and income in the following equation:

$$P_t = \sum_{i=1}^{\infty} \left[\frac{1}{\prod_{j=1}^{i} (1+\rho_{t+j})} \right] \cdot Q_{t+i}, \quad (1)$$

where P_t represents real housing price at the end of period t, Q_{t+i} stands for real disposable income in term t+i and ρ_t is the real discount rate. (1) is a particular solution to $P_t = (P_{t+1} + Q_{t+1})/1+\rho_{t+1}$. By taking its log and expanding it to the first order of Taylor's series, we can derive correlations between the variables through iteration by having t approach infinity in the following equation:[18]

$$pq_t = \frac{k}{1-\mu} + \sum_{i=0}^{\infty} \mu^i \Delta q_{t+i+1} + \sum_{i=0}^{\infty} \mu^i \Delta r_{t+i+1}. \quad (2)$$

In Equation (2), pq_t represent the ratio of housing price to income after taking the natural log, $r_{t+1} = \ln(1+\rho_{t+1})$, $p_{t+1} = \ln P_{t+1}$, $p_t = \ln P_t$, $q_{t+1} = \ln Q_{t+1}$ and $\mu = 1/1+\exp(\overline{q-p})$ with $0<\mu<1$, $k = -\ln\mu - (1-\mu)(\overline{q-p})$, $(\overline{q-p})$ stands for the sample mean of the ratio of housing price to income pq_t after taking the natural log. Finally, plugging in the same conditions of anticipation on both sides of the equal sign, we get:

$$pq_t = \frac{k}{1-\mu} + \sum_{i=0}^{\infty} \mu^i E_t \Delta q_{t+i+1} + \sum_{i=0}^{\infty} \mu^i E_t \Delta r_{t+i+1}. \quad (3)$$

In Equation (3), $E_t \Delta r_{t+i+1}$ stands for the return that investors expect and pq_t represents the log of housing price to income ratio estimation. Black et. al (2006) took the log of 3 variables (housing price to income ratio, income growth rate and the variance of housing price return) to derive the estimation of housing price to income ratio $(p/q)_t^*$ through VAR models for the three variables and took one step further to provide computation of fundamental pricing for real estate P_t^* as:

$$p_t^* = (p/q)_t^* + q_t. \quad (4)$$

Since the deviation of asset pricing from market fundamentals can be perceived as a bubble, and given the fact that real estate bubbles are random bubbles, the regression model for the study is configured as follows:[19]

[18] The derivation of Equation (2) see appendix C.

[19] Since the Equations are derived by the theoretical model, the control variables cannot be chosen completely arbitrary. And as such, despite the interest rate should be the important variable in the model, we still cannot insert the variable into the equation.

$$
\begin{aligned}
p_t &= \alpha(p/q)_t^* + \beta q_t + b_t + \varepsilon_t, \\
b_t &= \gamma b_{t-1} + e_t.
\end{aligned} \tag{5}
$$

In the equation above, $\alpha(p/q)_t^* + \beta q_t$ represents housing price based on market fundamentals and b_t represents the price bubble. $E(\varepsilon_t e_s) = 0$ and $t \neq s$, $E(e_t) = 0$, $V(e_t) = \sigma_e^2$. In the investigation of the impact of housing price to income ratio on housing price, the increase in income leads to rise in housing prices. The relationship between housing price to income ratio and housing price remains uncertain. Thus, in Equation (5), influence of disposable income on housing prices is expected as positive (i.e. the coefficient for $\beta > 0$). However, coefficient α that comes before $(p/q)_t^*$ could be either positive or negative.[20]

4.6 Data and Empirical Results

Considering the fact that Beijing and Shanghai are the largest cities across China, development of real estate in these two cities carries symbolic meaning. In addition to the nationwide data for China, the two cities of Beijing and Shanghai have also been chosen as targets of the empirical analysis.

4.6.1 Data Description and Unit Root Tests

The empirical analysis in this study was performed quarterly with target regions being the whole of China, Beijing and Shanghai. Nationwide data for the whole of China gathered during the period from Q1 of 2002 to Q1 of 2013 provided 45 observations whereas 40 observations were extracted from data for both Beijing and Shanghai, spanning Q1 of 2003 to Q4 of 2012. The source of the variable of disposable income is the website of the National Bureau of Statistics and the data of house prices are obtained from CEIC Database.

House prices are used by taking the commercial house selling price and per capita disposable income of urban population is plugged into the equation as disposable income. In this model, p, p/q and q represent housing price (in RMB/meter square), housing price to income ratio and per capita disposable income

[20] The increase in housing price to income ratio could result in both positive and negative impact on housing prices depending on the channel of supply and demand involved. To illustrate, when housing price to income ratio increases, households might expect housing prices to go up even further in the future and make the decision to purchase their own real estate (a factor of demand). It is also possible for real estate developers to perceive the trend as signs of a real estate bubble and thus cut down housing supply (a factor of supply), which would also drive up housing prices. On the other hand, an increase in housing price to income ratio might also cause demand for real estate to decline (a factor of demand) due to the fact that households would not be able to afford the real estate. Incidentally, real estate developers might also increase housing supply (a factor of supply) due to the incentive of profits, thereby lowering housing prices.

of urban population in the corresponding cities.

This study has adopted the Augmented Dickey-Fuller (ADF) method of Dickey and Fuller (1979) and Philips-Perron (PP) method of Phillips and Perron (1988) to test whether the time series is stationary. The results are listed in Table 4.6. After seasonally adjusting the data, results of ADF and PP unit root tests reveal that all variables become stationary time series after a first-order difference is taken.

Table 4.6: Unit Root Test for Housing Price Bubbles

		ADF test		PP test	
		Level	First-difference	Level	First-difference
China	p	1.60	-6.11***	1.72	-6.08***
	p/q	-2.10	-7.11***	-2.09	-7.16***
	q	2.70	-5.83***	3.90	-6.02***
Beijing	p	-0.64	-5.10***	-0.69	-5.11***
	p/q	-1.38	-5.20***	-1.48	-5.20***
	q	2.25	-9.80***	7.39	-9.80***
Shanghai	p	-0.74	-5.66***	-0.75	-5.65***
	p/q	-1.57	-5.41***	-1.74	-5.39***
	q	2.24	-5.44***	6.15	-5.43***

Note: ** and ***denote that the τ statistic is significant at 5% and 1% levels, respectively.

4.6.2 Empirical Results

Table 4.7 shows parameters of the empirical model obtained through the use of the Kalman Filter in a state space model and the maximum likelihood estimation method in a model constructed from observable variables. The results show that the estimation coefficient of α, β and γ for China, Beijing and Shanghai is significant at the 1% level. When the ratio of housing price against income goes up by one unit, housing price (RMB/meter square) in China and Beijing will increase by 1296.67 and 98.63 RMB, respectively. But prices in Shanghai will fall by 72.97 RMB. The results might be attributed to the fact that the potential consumers in markets of Beijing and Shanhai were not limited to local residents, as buyers might have come from other regions in China or abroad. When the ratio of housing price against income goes up, the investors expected substantial decrease in investment profits and cause demand for real estate to decline. And in order to meet the housing demand, when the ratio of housing price against income goes up, the households of China expect housing prices to go up even further in the future and make the decision to purchase their own real estate. When disposable income increases by 1 RMB, housing prices in China, Beijing and Shanghai would go up by 0.48, 0.02 and 0.05 RMB per

meter square, respectively. In addition, the estimated value of σ_e for China, Beijing and Shanghai is significantly different from zero at 1% level, which means the real estate market in China, Beijing and Shanghai in fact had bubbles during the span of this research.[21]

Table 4.6: Parameter Estimates: The State Space Model

	China	Beijing	Shanghai
α	1296.67***	98.63***	-72.97***
β	0.48***	0.02***	0.05***
γ	1.04***	-0.00***	0.03***
σ_e	0.48***	0.002***	8.58E-05***

Note: ** and ***denote that the z statistic is significant at 5% and 1% levels, respectively.

Based on the actual situation, sometimes fluctuations in housing prices and occurrence of a bubble cannot be explained through economic fundamentals. For example, the occurrence of a bubble might be caused by expectations of the general public, speculation by investors and even excessive interference from external forces. Such factors could cause housing prices to deviate significantly from economic fundamentals and lead to a bubble phenomenon. The following section shows a series of bubble pricing run charts for China, Beijing and Shanghai and diagrams illustrating the proportion of bubble pricing against housing prices. These figures offer better insights into the severity of China's real estate bubbles and the actual proportion of bubbles against housing prices.

Figures 4.2 to 4.4 are run charts of real estate bubble pricing in China (from Q1 2002 to Q1 2013), Beijing (from Q1 2003 to Q4 2012) and Shanghai (from Q1 2003 to Q4 2012). The empirical results reveal that although the pricing bubbles in China, Beijing and Shanghai have occasionally fluctuated, they still demonstrate a rising trend. The real estate pricing bubble in China has shown steady growth despite occasional fluctuations from Q1 2002 to Q1 2013, reaching its highest at 1,877.15 RMB/square meter in Q1 2013. Pricing bubble in Beijing reached 9,589.92 RMB/square meter in Q1 2011, which happened to be the highest pricing bubble in recent years. The bubble promptly plunged to 7,237.85 RMB/square meter in Q1 2012 before climbing back to 8,467.28 RMB/square meter in Q4 2012. The pinnacle of the pricing bubble in Shanghai occurred in Q1 2011 at 7697.65 RMB/square meter, which was a remarkable growth of 76.97% compared to the pricing bubble in Q1 2003.

[21] Since Equation (5) is derived by the theoretical model, the control variables cannot be chosen completely arbitrary. Accordingly, we cannot use robust test to test the robustness of the model.

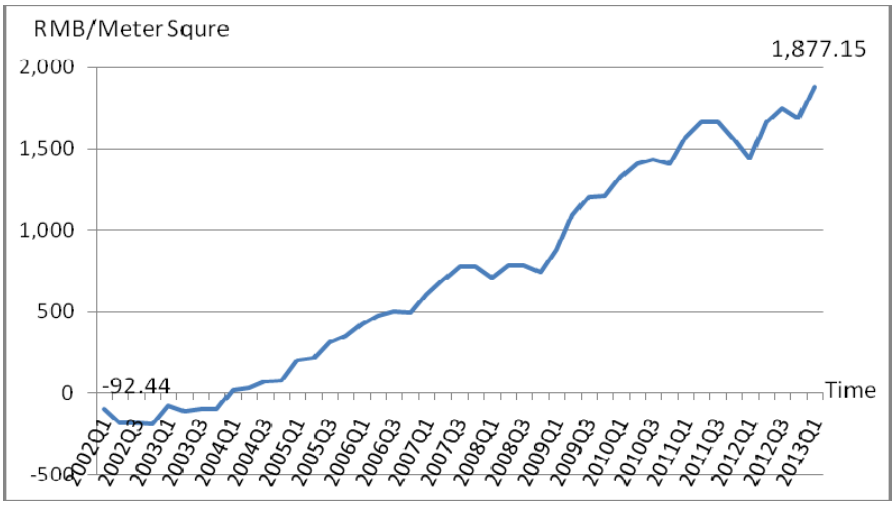


Figure 4.2: Real Estate Bubble Pricing in China

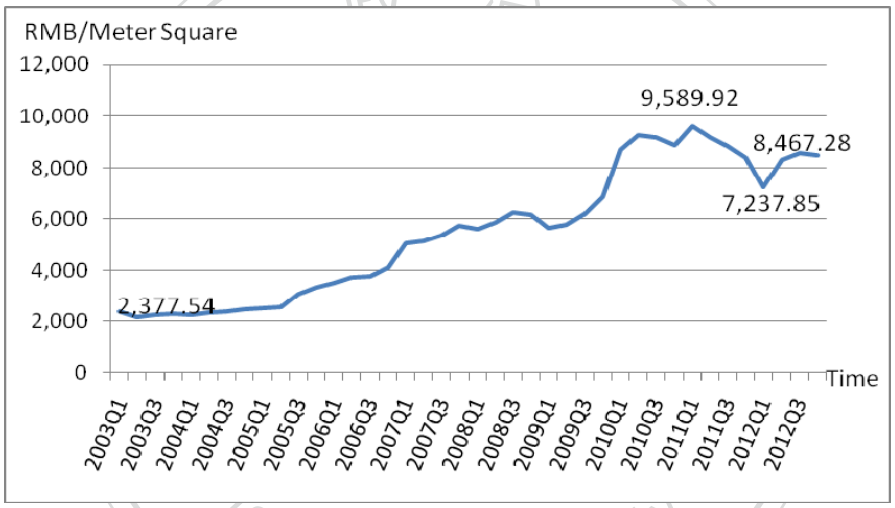


Figure 4.3: Real Estate Bubble Pricing in Beijing

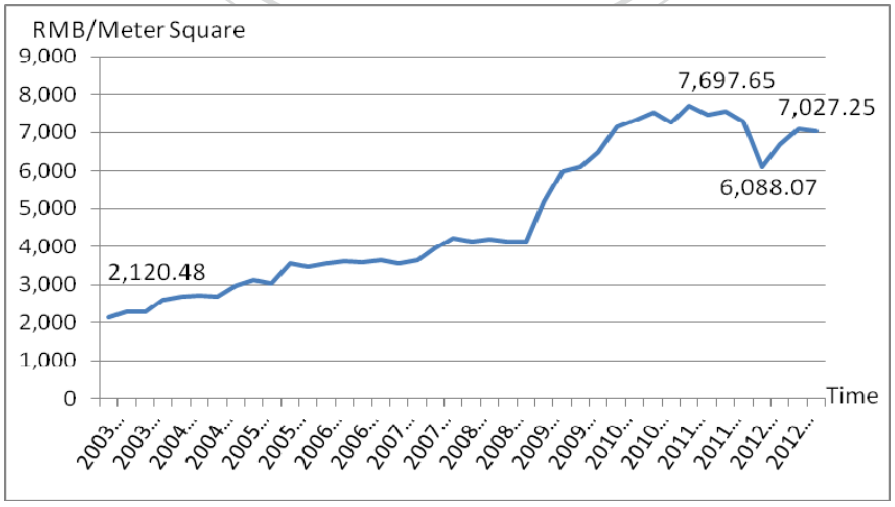


Figure 4.4: Real Estate Bubble Pricing in Shanghai

Although the series of macro-economic policies for the real estate market that the Chinese government has actively implemented between 2003 and 2012, a closer look at Figure 4.5 to Figure 4.7 reveals that the proportion of bubble pricing to housing price has actually been rising in recent years. In fact, the proportion started over from zero as early as the first quarter of 2004 and from Q1 2009 onward, the proportion began to dip over the 20% level and reached 28.91% in Q1 2013. It is worth noting that if one was to look at empirical data from the perspective of disposable income of Shanghai and Beijing residents against the relevant housing price data, it would become evident that the proportion of bubble pricing to housing price in Beijing's real estate market was the highest (84.75%) in Q1 2011. The proportion of bubble pricing to housing price in Shanghai's real estate market reached its peak of 50.19% in Q2 2010 and gradually dropped to 49.60% in Q4 2012.[22] The high proportion of bubble pricing to housing price in both Beijing and Shanghai might be attributed to the fact that potential consumers in both markets were not limited to local residents, as buyers might have come from other regions in China or abroad. As a result, household income of residents in Beijing and Shanghai might not be representative of local real estate buyers' purchasing power, i.e. external buyers might be causing the proportion to remain high.

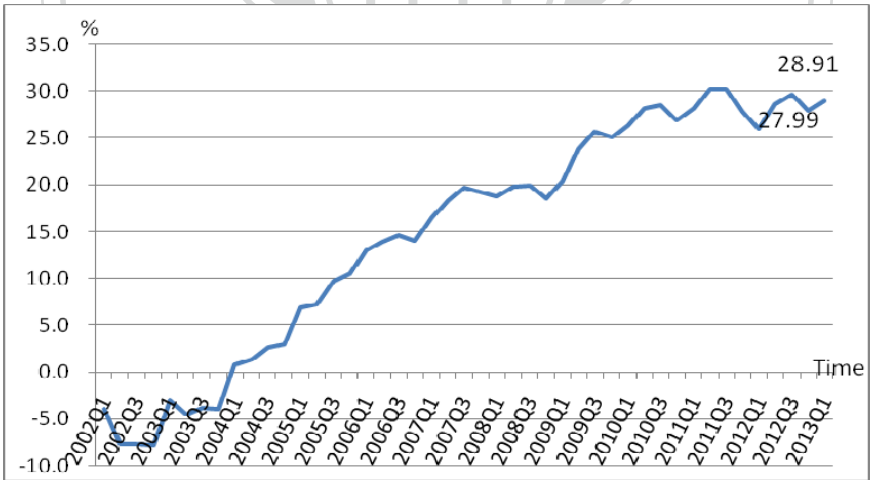


Figure 4.5: Proportion of Price Bubble to House Price
—— China

[22] These estimations of housing price bubbles are higher than the empirical results of Christian and Zhang (2010), Hui and Yue (2006), and Shen et al. (2005). Judging from the aforementioned literature, it would seem that the issue of real estate bubbles in China is not as serious as is believed. However, almost all of the empirical methods featured in these studies have adopted macro-econometric models which cause the problem of omission of key macroeconomic variables would lead to bias in estimation of bubbles.

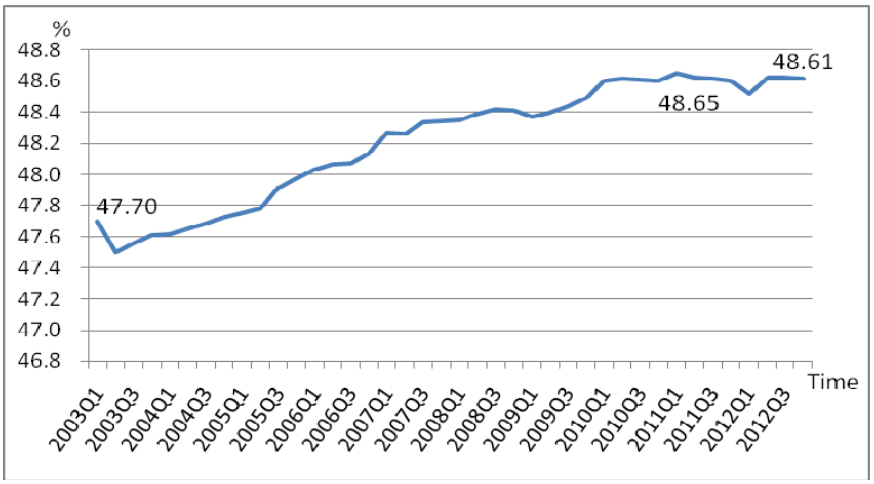


Figure 4.6: Proportion of Price Bubble to House Price — Beijing

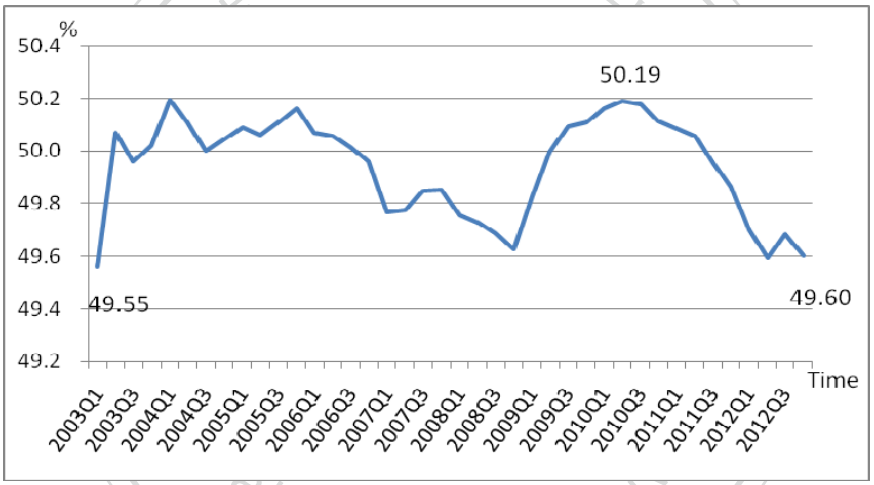


Figure 4.7: Proportion of Price Bubble to House Price — Shanghai

Beijing and Shanghai are the two largest cities of China. Beijing is the hub of politics, culture, science and education while Shanghai is renowned for industry, business, finance and technology. The rapid development and economic growth of both cities have drawn vast amounts of investments into their real estate market because of the promise of lucrative returns. Shanghai became the only city in China to surpass Beijing in terms of housing prices for the first time in 2003; real estate investment return rates reached 20~50% in 2005. The figure was substantially higher compared to Beijing (8~15%), United States (7%), Singapore (4%) and Japan (4%).[23] The impressive return rates caught the eyes of numerous investors from abroad also.

Foreign investors wishing to foray into China's real estate market through

[23] See Lutetong Statistics Research Center, *Real Estate Decision Making Reference*.

foreign direct investment can resort to two major channels of investment. One is to invest in real estate funds offered by international financial investment agencies to purchase real estate in China directly, and the other is acquisition of shares of listed real estate companies in China through equity investments. In addition to these legitimate ways of making real estate investments in China, some foreign investments have also found their way into the country through illegal trading channels.[24] Thus, it would be fairly difficult to make an accurate estimation of the amount of foreign investment in China's real estate market. However, the fact that foreign investments have driven up housing prices in China remains undeniable and consequently, the proportion of bubble pricing to housing price in both Beijing and Shanghai calculated based on the ratio of housing prices to income level seems to have been sustained at a high level.

In order to mitigate the negative impact that foreign investments have brought upon real estate market, the Chinese government promulgated its very first macro-economic policy to enforce regulations governing foreign investments in housing market in July 2006. In the years that followed, the government also enforced a number of regulations in an effort to alleviate the impact of foreign investments on China's housing market. In November 2010, the Ministry of Housing and Urban-Rural Development and the State Administration of Foreign Exchange jointly published the *Notice on Further Regulating the Administration on House Purchase by Overseas Institutions and Individuals*, which clearly states that foreign institutions and individuals are only entitled to purchase one housing unit for self-use. The notice is basically a stepped-up reiteration of the government's policy in 2006. However, since investments by foreign institutions in China's housing market were concentrated in relatively more advanced cities, policies that restrict foreign investment, promulgated by the Chinese government, have in fact affected only major cities like Beijing, Shanghai, Guangzhou and Shenzhen. Not only that, foreign institutions usually acquire stocks of Chinese real estate development firms indirectly through offshore funds rather than making direct purchases in the real estate market. Given these facts, the macro-economic policies that the Chinese government has implemented to restrict foreign investments in the real estate market have had a very limited effect.

In order to offset the impact on local housing prices caused by groups of real estate buyers from around the country, the Shanghai Municipal Government announced a house property tax on 28 January 2011. The tax is applicable to local

[24] These illegal practices include fabricating import and export prices of merchandise through foreign trading enterprises in China, fabricating false contracts without any trading background to allow foreign companies to remit funds into China in the name of prepayment. The funds would then be settled and deposited in RMB to invest in real estate market.

households buying second houses and foreign residents buying houses in Shanghai. The tax rate is 0.4~0.6% per annum, based on 70% of the actual transaction price. If the transaction price (RMB/square meter) for a housing unit is less than 200% of the average transaction price of new houses published by Shanghai Statistics for the first half of the year, the tax rate is reduced to 0.4%. In addition, in order to effectively clamp down on external speculative attacks on its local housing market, Beijing promulgated the strictest purchase restriction on 16 February 2011, stipulating that households not permanently registered in Beijing are required to provide tax declaration documentations substantiating payment of social insurance or personal income tax for five consecutive years in Beijing in order to be eligible to buy a housing unit in the city as a drastic measure to contain real estate speculation.

Although the Chinese government implemented the aforementioned real estate policies to suppress speculation and prevent formation of bubbles in the housing market of Beijing, Shanghai and the whole of China in general, the ratio in Q4 2012 remained as high as 48.61%, 49.60% and 27.99%, respectively, indicating that the problem of real estate bubble remained fairly serious. These figures also reveal that despite the resolve the Chinese government has shown to restore order to the nation's real estate market, the policies are yet to produce significant results.

The failure of real estate policies implemented prior to 2008 might have been attributed to the consideration of self-interest by local governments in China. Although most of the policies have emphasized stability of housing prices and clearly established the responsibilities that local governments must shoulder, these policies did not specifically state the role that local governments should play in implementation of these policies. The conflicts of interest have made it impossible for local governments to fairly and objectively regulate and supervise. In addition, the rise in housing prices has always been closely related to credit loans offered by the banking sector. A significant percentage of funding for real estate developers in China comes from bank loans, coupled with the high monthly amortization rates that households have to shoulder, the burst of real estate pricing bubbles could lead to liquidity risks in the financial sector and ultimately escalate into a full-blown financial crisis. The risks involved are simply too high to be ignored.

In light of this, the Chinese government has placed the responsibility of regulating the real estate market on local governments and requested them to assume liabilities for failure to curb high housing prices. In addition, since the trend of real estate purchase among the general public had been sparked by leverage manipulation in the banking sector, the Chinese government has also tried to combat speculation through regulation of loans and taxes in the hope of influencing people's expectations and putting real estate market development back on track.

The Chinese government is up against a daunting and unpredictable challenge in its attempt to resolve the real estate bubble in the country for obvious reasons. International funds may have already made their way into the domestic housing market through means such as acquisition of real estate by funds and investments in equity, which may result in more pronounced fluctuations in prices. Expectations of the general population present another element that is highly unpredictable. Although simulations of the effectiveness of government policies can be performed on open aggregate economic models, specific difficulties remain in their actual implementation. Although the approach of limiting bank credit loans and raising the requirement of own funds ratio for real estate developers might be effective for local enterprises, the method would do little to stop foreign institutions that have vast funds at their disposal. In order to thoroughly resolve the issue of real estate bubble in China, the government should adopt a gradual but comprehensive approach.

In terms of policies on housing demand, the Chinese government should aggressively develop a secondary market and a rental market to cultivate the right patterns of housing consumption while carrying out house property tax reforms to curb speculative housing demand.[25] At the same time, the government should educate the people to take their income and purchasing power into consideration prior to buying houses to prevent their monthly amortization rate to unsustainable levels. Besides, in addition to increasing the effective supply of housing, the government should also actively develop relevant transportation infrastructure to improve accessibility and land utilization (i.e. improving urban planning and capacity management). Not only that, the government should also take steps to ensure the demand for middle-low-income families is met (i.e. construction, development, management and allocation of government-subsidized housing). Lastly, the government should be more cautious and meticulous in its evaluation of thresholds for foreign investments so as to resolve the existing problem of real estate bubbles at the root.

4.7 Summary

Since 1998, with support from economic fundamentals such as macro-economic growth, industrialization, urbanization and the rise of the middle class, China's real estate has shown rapid growth. However, injection of vast amounts of funds into the

[25] The structure of China's current real estate market is overly reliant on the market of newly constructed houses. As a result, the term "housing prices" has almost become synonymous with the price for newly constructed houses. Through active development of a secondary market and a rental market, the government would be able to divert people's demand for new houses and accommodate their housing demand through the secondary market and rental market to suppress housing prices.

housing market has caused prices to skyrocket, gradually reaching levels that are beyond the average household's income level, sparking much inter-disciplinary debate on real estate bubbles. Since pricing bubbles were the unobservable variables, an estimation of pricing bubbles has been made using the maximum likelihood method through a state space model and recursive computation of the Kalman Filter. Results of empirical analyses reveal that price bubbles do exist in housing markets of Beijing, Shanghai and the whole of China in general. Concrete observations of relevant policy measures and their effects suggest that the Chinese government has spared no efforts in its attempt to regulate the real estate market and yet housing prices in China have remained high and the issue of bubble pricing remains unaddressed. The lack of effectiveness of policy measures implemented by the Chinese government could be attributed to the conflicting mentalities demonstrated by competent authorities responsible for control and regulation of the real estate market.

Following China's reform and economic development in recent years, the nation's real estate industry has rapidly evolved into a pillar of China's national economy and the economic bloodline in some cities. However, concentration of resources in specific industries can cause imbalances in national economic activities which may even lead to the risk of limiting the moment of growth to specific domains. The real estate industry plays a pivotal role in development of several industries, including metallurgy, construction materials, household appliances and the financial industry. Given its enormous influence, China's real estate market has been officially documented as a pillar industry of national economy in 2003 by the State Council. Nonetheless, it is also an undeniable fact that current housing prices in China have significantly deviated from the general population's purchasing power. The real estate market is not an independent economic phenomenon and among the numerous factors that drive up housing prices, foreign investment, speculation and substantial increase of money in circulation adopted by the central government have played critical roles. Therefore, policies designed to regulate housing prices should place greater emphasis on general coordination among policies. In addition to promotion of government-subsidized housing construction to curb rising housing prices, policies should also function in conjunction with the government's foreign exchange policies to deter speculative foreign investment. Not only that, the government should also adjust relevant macro-economic policies in order to ensure that real estate bubbles are adequately resolved.

Chapter 5
Conclusions

China's economic performance over the past quarter of a century has been one of the strongest in history. Following years of rapid expansion, China has become one of the world's largest economies. Due to a continuous inflow of capital and the commitment to maintain a fixed rate against the dollar initially and then a crawling peg exchange rate regime, China has experienced a large increase in its foreign exchange reserves since 2001. In recent years, in order to stabilize the exchange rate of the RMB and further realize the sustainable development of China's economy in the context of persistent balance of payments surplus and intensified pressure on the RMB appreciation, the PBC has been using a variety of sterilization instruments. In the mid 1990s, the callback of central bank's relending was the major tool for PBC's sterilization. In the past decade, PBC began to rely on two new tools to sterilize: issuing central bank bills and raising required reserve ratios (Zhang, 2012).

As a result, Chinese government has adopted a policy mix of managed exchange rates, while still trying to maintain domestic monetary control and growing financial integration and accomplished this with a policy combination of massive reserve hoarding and sterilization. A useful perspective for understanding the changing configuration of monetary policy by developing countries is provided by applying the framework of the impossible trinity dilemma –the trilemma. The trilemma states that a country simultaneously may choose any two, but not all, of the following three goals: monetary independence, exchange rate stability and financial integration (Obstfeld et al., 2005). China has faced an increasing trilemma—how to maintain independent monetary policy and limit exchange rate flexibility simultaneously, while at the same time facing persistent and substantial international capital flows (Wang, 2010).

Thus, in chapter 2, based on microeconomic foundations and with the perspective of minimizing the target loss function of monetary authorities, this study aims to construct a refined model for offset and sterilization coefficient estimation to evaluate the effectiveness of China's sterilization policy. Besides, empirical data are used to further explore financial capabilities of the central bank in order to understand the sustainability of the sterilization policy. The empirical results show that Chinese monetary authorities sterilize almost all effects of international capital inflows and increase in foreign exchange reserves on the monetary base. That is, increase in capital liquidity does not sabotage the independence of the Chinese monetary policy. Nevertheless, analyses of sustainability of the sterilization policy indicate that the sustainability of the monetary sterilization policy has been seriously challenged since

March 2008.

The speculative capital inflow is believed to have fueled inflation, driven up stock prices, and helped accelerate a worrisome bubble in the real estate market (Zhang and Fung, 2006). In the context of heightening expectations of RMB appreciation, inflows of short-term international capital for speculative purposes are considered to be an important factor contributing to the formation of housing price bubbles and stock price volatility. Kuo and Huang (2010) investigate the extent of the impact from “hot money” or speculative capital inflow on the fluctuations of China's real estate market and stock market. They indicate that hot money has driven up property prices as well as contributed to the accelerating volatilities in both markets due to its enormous size and its short-term characteristic of investing. Besides, the central bank opts for converting the external pressure for RMB appreciation to the internal momentum for monetary expansion. This has aggravated the problem of excess liquidity in the asset market. In the context of rising foreign exchange reserves and monetary authorities being unable to sterilize all funds outstanding for foreign exchange due to foreign exchange market interventions, increases in asset prices have gradually made people question the interaction between short-term capital inflows and asset prices that contributes to asset price bubbles.

In chapter 3, we employ a SVAR model to analyze the relationships among the unsterilized portion of the monetary base, short-term international capital inflows, and asset prices. The empirical evidence demonstrates that the relationship between short-term international capital inflows and asset prices is self-fufilling and mutually reinforcing. The unsterilized portion of the monetary base further exacerbates asset price bubbles.

The massive short-term international capital inflows presents various dangers to China’s economy since it can move very quickly in and out of a market, and has the potential to create bubbles in the stock market and real estate market. In order to mitigate the negative impact that foreign investments have brought upon real estate market, the Chinese government promulgated its very first macro-economic policy to enforce regulations governing foreign investments in housing market in July 2006. In the years that followed, the government also enforced a number of regulations in an effort to alleviate the impact of foreign investments on China’s real estate market.

In order to investigate whether there was a housing price bubble in Beijing, Shanghai and the whole of China. In chapter 4, we use the maximum likelihood method through the use of a state space model and recursive computation of the Kalman Filter to estimate the housing price bubbles in China. Although the Chinese government implemented the aforementioned real estate policies to suppress speculation and prevent formation of bubbles in the housing market, our evidence

reveals that price bubbles do exist in housing markets of Beijing, Shanghai and the whole of China in general, the ratio in Q4 2012 remained as high as 48.61%, 49.60% and 27.99%, respectively, indicating that the problem of real estate bubble remained fairly serious. These figures also reveal that despite the resolve the Chinese government has shown to restore order to the nation's real estate market, the policies are yet to produce significant results.

As speculation in the real estate and stock markts exerts negative impacts on the transformation of Chinese economy, heightened asset price volatility leads to strong expectations of inflation or deflation in the future macroeconomic environment, which threatens financial stability. In order to maintain steady economic growth and development, the Chinese government should focus on policy coordination. Despite adopting a flexible foreign exchange rate system, the authority shall foster a well-rounded financial market to formulate a more reasonable interest rate policy, provide a better environment for the RMB exchange rate reform, and adopt strict controls over credit loans for speculative investment in asset markets. All of these will effectively prevent the domestic financial system from being severely impacted by asset price bubbles due to short-term international capital inflows, and further maintain normal functioning of financial markets and sustainable economic development.

Appendix A: Derivation of the Change in the Exchange Rate

This appendix provides a detailed derivation of Eq. (5), rewritten in the functional style in the text. First, the change in net foreign assets is defined as follows:

$$\Delta NFA_t = CA_t + \Delta NK_t, \tag{A1}$$

where CA_t is the current account surplus and ΔNK_t is the net capital inflow at time t. Second, the current account surplus and the net capital inflow are defined in the following:[26]

$$CA_t = \lambda_0 - \lambda_1 Y_{ct} - \lambda_2 \Delta REER_{t-1}, \qquad \lambda_1 > 0, \lambda_2 > 0 \tag{A2}$$

$$\Delta NK_t = \left(\frac{1}{c}\right)\Delta\left(e_t - Ee_{t+1} + r_t - r_t^* + r_{s,t} - r_{s,t}^*\right), \tag{A3}$$

where $REER_{t-1}$ is the real effective exchange rate in time $(t-1)$; e_t is the exchange rate at time t; Ee_{t+1} is the expected exchange rate at time $(t+1)$; r_t is the domestic interest rate; r_t^* is the foreign interest rate; $r_{s,t}$ and $r_{s,t}^*$ are yields of domestic and foreign investment, respectively. c denotes the degree of substitution and capital controls between domestic and foreign assets. When c = 0, domestic and foreign assets are perfect substitutes and capital is perfectly mobile; when c = ∞, domestic and foreign assets cannot be substituted for each other and capital is fully controlled for. Since domestic and foreign assets can be substituted for each other to a certain degree, we assume $0 < c < \infty$.

Substituting Equations (A2) and (A3) into (A1) means:

$$\Delta NFA_t = \left(\lambda_0 - \lambda_1 Y_{ct} - \lambda_2 \Delta REER_{t-1}\right) + \left(\frac{1}{c}\right)\Delta\left(e_t - Ee_{t+1} + r_t - r_t^* + r_{s,t} - r_{s,t}^*\right),$$

moving Δe_t to the left-hand side of the equation gives:

$$\Delta e_t = c\left(\Delta NFA_t - \lambda_0 + \lambda_1 Y_{ct} + \lambda_2 \Delta REER_{t-1}\right) + \Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)]$$

$$= c\Delta NFA_t - c\lambda_0 + c\lambda_1 Y_{ct} + c\lambda_2 \Delta REER_{t-1} + \Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)], \tag{A4}$$

substituting Equation (3) into (A4) obtains the following assumptions on exchange rate volatility.

$$\Delta e_t = -c\lambda_0 + (c + c\lambda_1\omega_1 mm_t)\Delta NFA_t + (c\lambda_1\omega_1 mm_t)\Delta NDA_t +$$

$$(c\lambda_1\omega_1 MB_t)\Delta mm_t + (c\lambda_1\varpi_2)Y_{c,t-1} + (c\lambda_1\varpi_3)\Delta G_{c,t} + (c\lambda_2)\Delta REER_{t-1} +$$

[26] The specification of current account surplus is based on the model outlined in Ouyang et al. (2008). The current account in turn is assumed to depend simply on both cyclical output and the lagged real effective exchange rate. As high investment yields in China's capital market, along with China's exchange rate appreciation and the interest rate spread, is important to foreign investors, we include the yield gap between domestic and foreign investments in the specification of net capital inflows.

$$\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)$$

This is the Equation (5) in this study.

Appendix B: Derivation of the Change in Net Foreign Assets and Net Domestic Assets

This appendix provides a detailed derivation of Eq. (8) and (9), rewritten in the functional style in the text. First, the partial derivatives with respect to ΔNFA_t and ΔNDA_t are defined as follows:

$$\begin{aligned}\partial L_t/\partial \Delta NFA_t &= (\partial L_t/\partial \Delta p_t)(\partial \Delta p_t/\partial \Delta NFA_t) + (\partial L_t/\partial Y_{c,t})(\partial Y_{c,t}/\partial \Delta NFA_t) + \\ &\quad (\partial L_t/\partial Y_{c,t})(\partial Y_{c,t}/\partial \Delta NFA_t) \\ &= (2\alpha \Delta p_t)(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t) + (2\beta Y_{c,t})(\varpi_1 mm_t) + (2\gamma H_{c,t})(\phi_1 mm_t) \\ &= 0, \end{aligned} \tag{B1}$$

$$\begin{aligned}\partial L_t/\partial \Delta NDA_t &= (\partial L_t/\partial \Delta p_t)(\partial \Delta p_t/\partial \Delta NDA_t) + (\partial L_t/\partial Y_{c,t})(\partial Y_{c,t}/\partial \Delta NDA_t) + \\ &\quad (\partial L_t/\partial Y_{c,t})(\partial Y_{c,t}/\partial \Delta NFA_t) \\ &= (2\alpha \Delta p_t)(\tau_1 mm_t + \tau_3 c\lambda_1 \omega_1 mm_t) + (2\beta Y_{c,t})(\varpi_1 mm_t) + (2\gamma H_{c,t})(\phi_1 mm_t) \\ &= 0, \end{aligned} \tag{B2}$$

substituting Equations (3), (5) and (7) in (B1) generates:

$$\begin{aligned}&\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)\Delta NFA_t + \\ &\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_1 mm_t + \tau_3 c\lambda_1 \omega_1 mm_t)\Delta NDA_t + \\ &\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_1 MB_t + \tau_3 c\lambda_1 \omega_1 MB_t)\Delta mm_t + \\ &\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_2)\Delta p_{t-1} + \\ &\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_3 c\lambda_1 \varpi_2)Y_{c,t-1} + \\ &\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_3 c\lambda_1 \varpi_3)\Delta G_t + \\ &\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_3 c\lambda_2)\Delta REER_{t-1} + \\ &\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1 \omega_1 mm_t)(\tau_3)\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)] + \\ &\beta(\varpi_1 mm_t)(\varpi_1 mm_t)\Delta NFA_t + \beta(\varpi_1 mm_t)(\varpi_1 mm_t)\Delta NDA_t + \end{aligned}$$

$$\beta(\varpi_1 mm_t)(\varpi_1 MB_t)\Delta mm_t + \beta(\varpi_1 mm_t)(\varpi_2)Y_{c,t-1} + \beta(\varpi_1 mm_t)(\varpi_3)\Delta G_{c,t} +$$

$$\gamma(\phi_1 mm_t)(\phi_1 mm_t)\Delta NFA_t + \gamma(\phi_1 mm_t)(\phi_1 mm_t)\Delta NDA_t +$$

$$\gamma(\phi_1 mm_t)(\phi_1 MB_t)\Delta mm_t + \gamma(\phi_1 mm_t)(\phi_2)H_{c,t-1} = 0,$$

rearranging the above equation gives the following formula:

$$[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)^2 + \beta(\varpi_1 mm_t)^2 + \gamma(\phi_1 mm_t)^2]\Delta NFA_t +$$

$$[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t) + \beta(\varpi_1 mm_t)^2 + \gamma(\phi_1 mm_t)^2]\Delta NDA_t +$$

$$\{\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 MB_t + \tau_3 c\lambda_1\omega_1 MB_t) + [\beta(\varpi_1)^2 + \tau(\phi_1)^2]mm_t MB_t\}\Delta mm_t +$$

$$\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_2)\Delta p_{t-1} + \gamma(\phi_1 mm_t)(\phi_2)H_{c,t-1}$$

$$[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_2) + \beta(\varpi_1 mm_t)(\varpi_2)]Y_{c,t-1} +$$

$$[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_3) + \beta(\varpi_1 mm_t)(\varpi_3)]\Delta G_t +$$

$$\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_2)\Delta REER_{t-1} +$$

$$\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3)\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)] = 0,$$

moving the term of ΔNFA_t to the left-hand side of the equation gives:

$$\Delta NFA_t =$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t) + \beta(\varpi_1 mm_t)^2 + \gamma(\phi_1 mm_t)^2]/\eta_1\}\Delta NDA_t +$$

$$\{\{\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 MB_t + \tau_3 c\lambda_1\omega_1 MB_t) + [\beta(\varpi_1)^2 + \gamma(\phi_1)^2]mm_t MB_t\}/\eta_1\}\Delta mm_t +$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_2)]/\eta_1\}\Delta p_{t-1} + \{[\gamma(\phi_1 mm_t)(\phi_2)]/\eta_1\}H_{c,t-1}$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_2) + \beta(\varpi_1 mm_t)(\varpi_2)]/\eta_1\}Y_{c,t-1} +$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_3) + \beta(\varpi_1 mm_t)(\varpi_3)]/\eta_1\}\Delta G_t +$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_2)]/\eta_1\}\Delta REER_{t-1} +$$

$$\{\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3)/\eta_1\}\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)], \qquad \text{(B3)}$$

where $\eta_1 = -[\alpha(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)^2 + \beta(\varpi_1 mm_t)^2 + \gamma(\phi_1 mm_t)^2] < 0$.

Substituting Equations (3), (5) and (7) in (B2) generates:

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t)\Delta NFA_t +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)\Delta NDA_t +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 MB_t + \tau_3 c\lambda_1\omega_1 MB_t)\Delta mm_t +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_2)\Delta p_{t-1} +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_2)Y_{c,t-1} +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_3)\Delta G_t +$$

$$\alpha(\tau_1 mm_t + \gamma_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_2)\Delta REER_{t-1} +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3)\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)] +$$

$$\beta(\varpi_1 mm_t)(\varpi_1 mm_t)\Delta NFA_t + \beta(\varpi_1 mm_t)(\varpi_1 mm_t)\Delta NDA_t +$$

$$\beta(\varpi_1 mm_t)(\varpi_1 MB_t)\Delta mm_t + \beta(\varpi_1 mm_t)(\varpi_2)Y_{c,t-1} + \beta(\varpi_1 mm_t)(\varpi_3)\Delta G_{c,t} +$$

$$\gamma(\phi_1 mm_t)(\phi_1 mm_t)\Delta NFA_t + \gamma(\phi_1 mm_t)(\phi_1 mm_t)\Delta NDA_t +$$

$$\gamma(\phi_1 mm_t)(\phi_1 MB_t)\Delta mm_t + \gamma(\phi_1 mm_t)(\phi_2)H_{c,t-1} = 0,$$

rearranging the above equation gives the following formula:

$$[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t) + \beta(\varpi_1 mm_t)^2 \gamma(\phi_1 mm_t)^2]\Delta NFA_t +$$

$$[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)^2 + \beta(\varpi_1 mm_t)^2 + \gamma(\phi_1 mm_t)^2]\Delta NDA_t +$$

$$\{\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 MB_t + \tau_3 c\lambda_1\omega_1 MB_t) + [\beta(\varpi_1)^2 + \gamma(\phi_1)^2]mm_t MB_t\}\Delta mm_t +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_2)\Delta p_{t-1} + \gamma(\phi_1 mm_t)(\phi_2)H_{c,t-1} +$$

$$[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_2) + \beta(\varpi_1 mm_t)(\varpi_2)]Y_{c,t-1} +$$

$$[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_3) + \beta(\varpi_1 mm_t)(\varpi_3)]\Delta G_{c,t} +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_2)\Delta REER_{t-1} +$$

$$\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3)\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)] = 0,$$

moving the term of ΔNDA_t to the left-hand side of the equation gives:

$$\Delta NDA_t =$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 mm_t + \tau_3 c + \tau_3 c\lambda_1\omega_1 mm_t) + \beta(\varpi_1 mm_t)^2 + \gamma(\phi_1 mm_t)^2]/\eta_2\}\Delta NFA_t +$$

$$\{\{\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_1 MB_t + \tau_3 c\lambda_1\omega_1 MB_t) + [\beta(\varpi_1)^2 + \gamma(\phi_1)^2]mm_t MB_t\}/\eta_2\}\Delta mm_t +$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_2)]/\eta_2\}\Delta p_{t-1} + \gamma(\phi_1 mm_t)(\phi_2)H_{c,t-1} +$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_2) + \beta(\varpi_1 mm_t)(\varpi_2)]/\eta_2\}Y_{c,t-1} +$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_2)]/\eta_2\}\Delta REER_{t-1} +$$

$$\{[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3 c\lambda_1\varpi_3) + \beta(\varpi_1 mm_t)(\varpi_3)]/\eta_2\}\Delta G_{c,t} +$$

$$\{\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)(\tau_3)/\eta_2\}\Delta[Ee_{t+1} - (r_t - r_t^*) - (r_{s,t} - r_{s,t}^*)], \qquad \text{(B4)}$$

where $\eta_2 = -[\alpha(\tau_1 mm_t + \tau_3 c\lambda_1\omega_1 mm_t)^2 + \beta(\varpi_1 mm_t)^2 + \gamma(\phi_1 mm_t)^2] < 0$

Generalizing Equations (B3) and (B4) obtains Equations (8) and (9) in the study.

Appendix C: Derivation of the First Order of Taylor's Series

From Equation (1), using the particular solution $P_t = (P_{t+1} + Q_{t+1})/1 + \rho_{t+1}$, take the log to derive:

$$\begin{aligned}
\ln(1+\rho_{t+1}) &= \ln(P_{t+1} + Q_{t+1}) - \ln P_t \\
&= \ln(P_{t+1} + Q_{t+1}) - \ln P_{t+1} + \ln P_{t+1} - \ln P_t \\
&= \ln[(P_{t+1} + Q_{t+1})/P_{t+1}] + \ln P_{t+1} - \ln P_t \\
&= \ln[1 + (Q_{t+1}/P_{t+1})] + \ln P_{t+1} - \ln P_t \\
&= \ln[1 + \exp\ln(Q_{t+1}/P_{t+1})] + \ln P_{t+1} - \ln P_t \\
&= \ln[1 + \exp(q_{t+1} - p_{t+1})] + p_{t+1} - p_t .
\end{aligned}$$

From the equation above, $p_{t+1} = \ln P_{t+1}$, $p_t = \ln P_t$ and $q_{t+1} = \ln Q_{t+1}$. Let $r_{t+1} = \ln(1+\rho_{t+1})$, $p_{t+1} = \ln P_{t+1}$, $p_t = \ln P_t$ and $q_{t+1} = \ln Q_{t+1}$, we can derive the following:

$$r_{t+1} = \ln[1 + \exp(q_{t+1} - p_{t+1})] + p_{t+1} - p_t . \qquad \text{(C1)}$$

For the next step, take the part of $\ln[1+\exp(q_{t+1} - p_{t+1})]$ from (C1) and use Taylor's series in $(\overline{q-p})$ for first-order Taylor expansion:

$$r_{t+1} = \ln[1 + \exp(\overline{q-p})] + \frac{\exp(\overline{q-p})}{1+\exp(\overline{q-p})}[(q_{t+1} - p_{t+1}) - (q-p)] + p_{t+1} - p_t$$

$$= -\ln\left[\frac{1}{1+\exp(\overline{q-p})}\right] - \left[1 - \frac{1}{1+\exp(\overline{q-p})}\right](q-p) + \frac{\exp(\overline{q-p})}{1+\exp(\overline{q-p})}(q_{t+1} - p_{t+1}) + p_{t+1} - p_t .$$

And plugging in + and – of $\frac{(q_{t+1} - p_{t+1})}{1+\exp(\overline{q-p})}$ and q_t on the right side of the equal sign, we get:

$$r_{t+1} = -\ln\left[\frac{1}{1+\exp(\overline{q-p})}\right] - \left[1 - \frac{1}{1+\exp(\overline{q-p})}\right](\overline{q-p}) + \frac{\exp(\overline{q-p})}{1+\exp(\overline{q-p})}(q_{t+1} - p_{t+1}) +$$

$$\frac{1}{1+\exp(\overline{q-p})}(q_{t+1}-p_{t+1})-\frac{1}{1+\exp(\overline{q-p})}(q_{t+1}-p_{t+1})+p_{t+1}-p_t+q_t-q_t$$

$$=-\ln\left[\frac{1}{1+\exp(\overline{q-p})}\right]-\left[1-\frac{1}{1+\exp(\overline{q-p})}\right](\overline{q-p})+(q_{t+1}-p_{t+1})-\frac{1}{1+\exp(\overline{q-p})}(q_{t+1}-p_{t+1})+$$

$$p_{t+1}-p_t+q_t-q_t$$

$$=-\ln(\mu)-(1-\mu)(\overline{q-p})+\mu(p_{t+1}-q_{t+1})+(q_{t+1}-q_t)-(p_t-q_t)$$

$$=-(p_t-q_t)+\mu(p_{t+1}-q_{t+1})+\Delta q_{t+1}+k\,. \qquad \text{(C2)}$$

In the equation above, $\mu=1/1+\exp(\overline{q-p})$ and $0<\mu<1$, $k=-\ln\mu-(1-\mu)(\overline{q-p})$, $(\overline{q-p})$ represents the sample mean of (q_t-p_t). When t approaches infinity, we can arrive at the following correlation among the variables through the process of iteration:

$$(p_t-q_t)=\frac{k}{1-\mu}+\sum_{i=0}^{\infty}\mu^i\Delta q_{t+i+1}+\sum_{i=0}^{\infty}\mu^i\Delta r_{t+i+1}\,. \qquad \text{(C3)}$$

Let pq_t represent the ratio of housing price to income (p_t-q_t) after taking the natural log, we can then rewrite (C3) into Equation (2) as established in the earlier section.

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