Financial Globalization and the International Transmission of Interest Rate Shocks: The Federal Reserve and China*

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Abstract

This paper evaluates the spillovers from U.S. monetary policy to China's domestic interest rates over 1999-2016, focusing on the impacts of long-term interest rate and exchange rate regimes on the capacity of China to moderate external interest rate shocks. We find that China's central bank owns some extent of autonomy as it has a significant preference to control inflation and stimulate the economy even beyond the potential growth. However, China's interest rates are significantly impacted by U.S. monetary policy especially after the crisis. The transmission from U.S. interest rates to China at the long-end even exists before the crisis, but only for the positive change of U.S. interest rates. The comparison with New Zealand's experience provides some evidence that central banks are more likely facing a "monetary dilemma" and China's fixed exchange rate regime with capital controls might help to mitigate the spillovers of external monetary shocks in a turmoil period.

Keywords: Interest Rates, Federal Reserve, International Transmission

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1. Introduction

One of the central macroeconomic questions is whether the central bank can assert more monetary autonomy with a more flexible exchange rate regime. This issue is traditionally summarized by the Mundellian trilemma, which states that it is not feasible to have at the same time a fixed exchange rate, full capital mobility and monetary independence. Only two of them can be achieved simultaneously. However, after the Global Financial Crisis of 2007/8 (GFC) which has been the most severe and costly crisis since the Great Recession, many long-held views about the global financial system have been questioned. One of the key topics of the debate refers to the capacity of monetary authority isolating international monetary policy shocks under the ongoing rapid development of financial globalization.

The debate comes from the rethinking of effects of massive international capital flows and the international transmission of monetary policy, including the unconventional monetary policy (UMP) adopted by the major central banks in the world since GFC. A large literature has examined the international transmission of the Fed's UMP on global financial markets. Most of them, including Hausman and Wongswan(2011), Chen *et al.* (2012), Bowman *et al.* (2015), Neely(2015) and MacDonald(2017), provide evidence that UMP announcement and operations can induce an obvious and large spillover effect to foreign assets prices via signalling, portfolio shifting and risk taking channels. In particular, Fratzscher *et al.* (2013) and Moore, *et al.* (2013) suggest that the Fed's quantitative easing and forward guidance encouraged capital flows to EMEs and raised their asset prices. Rey (2013) further points out that persistent capital flows across borders via global banks or non-bank institutions in search of arbitrage opportunities in the flourishing international capital market have generated a separate "Global financial Cycle"; viz., a very large panel of risky asset returns around the world exhibiting a high degree of co-movement. This financial cycle does not coincide with the real economy momentum but driven instead by U.S. monetary policy, which in turn

affects the leverage of global banks and credit growth. These developments have opened a new debate about the role of monetary and macroprudential policies including the role of capital controls. Contrasting the traditional Mundell-Fleming model, recently, some authors, including Frankel *et al.* (2004), have argued that countries with flexible exchange rates cannot obtain true monetary autonomy. Rey *et al.* (2015) further points out that international financial integration exposes emerging market economies to new sources of shocks to the economy (the "global financial cycle") and "monetary policy independence is possible if and only if the capital account is managed, directly or indirectly, regardless of the exchange rate regime." However, this new view about the “monetary dilemma” has been challenged by some studies. Hausman and Wongswan (2011) and Bowman *et al.* (2015) find that the spillover effect of U.S. monetary policy shocks on foreign stock prices and interest rates are larger in countries with less flexible exchange regimes. Obstfeld (2015) asserts the ability of emerging market economies (EMEs) to conduct their own monetary policy under the flexible exchange rates.

Although the debate is still going on among the researchers, many countries, especially the EMEs, have already placed more restrictions on capital mobility and kept a managed floating exchange rate regime. Some interesting questions arise in this context. Can these measures help the central banks to moderate the external monetary policy shocks? Is there any difference for the spillover effects from the US to EMEs after the global financial crisis? These questions have not been fully examined, especially within the content of a large developing economy and financial system as that of China.

China's monetary and foreign exchange policy has been highly controversial in the past decades and will continue to attract extensive attention in the foreseeable future as its prominent scale on the worldwide economy is rising and is moving ahead with the internationalization process of RMB in the global financial system. Although China is

increasingly integrated with the global economy, the pace of integration of its financial sectors is much slower than that its trade sectors. Since its opening-up policy launched in 1978, China has grown rapidly from a closed and underdeveloped economy to the world's largest trading partner, especially after joining the WTO in December 2011. However, China is still quite conscientious of opening up its financial sector despite loosening up restrictions on its financial markets and capital account. Regulations on external sectors, including capital controls, managed exchange rates and sterilized interventions, are still in place to restrict and manage cross-border capital movements. On the other hand, the People's Bank of China (PBC) continues to implement reform monetary policy tools to be more market-oriented. Before the middle of the 1990s, PBC mostly used monetary aggregates and administrative guidance as the tools, for example, credit quotas, while it is moving to adopt more market driven interest rate tools through open market operations to attain its multiple policy objectives including macroeconomic and financial stability.

The traditional literature on China' optimal monetary policy, including the most recent research by Chang, Liu and Spiegel (2015), largely share the view that capital account and exchange rate liberalization would allow the Chinese central bank to better stabilize the external shocks and achieve better macroeconomic stability. But is this true when the global financial cycle in conjunction with UMP are taken into account? Specifically, to what extent China's interest rates are affected by the U.S. monetary policy actions, inclusive of conventional policy tools, e.g. the federal funds rate, and the unconventional monetary policies. To investigate these issues, we employ monthly data from 1999 to 2016, encompassing multiple episodes of fixed exchange rates and managed float before and after the crisis. We use the Non-linear ARDL model, developed by Shin *et al.* (2014), to estimate the spillover effects of U.S. monetary policy to China's domestic interest rates, including the policy rate, short-term and long-term rates. In particular, we focus on the role of long-term

interest rates and the exchange rate regime in the international transmission taking into account global financial factors and the effects of unconventional monetary policy.

Our main findings are summarized as follows. Firstly, although China's central bank commands some autonomy as it does respond to domestic fundamentals, the spillover effects of U.S. monetary policy are significant and strong to China's short-term interest rates after the crisis. The international transmission of U.S. monetary policy at the long-end even holds before the crisis, but only for positive changes of U.S. long-term interest rates. This might be due to the investors' expectations on both the ability and the preference of China's government to offset the negative shock of external demand slowdown by stimulating the domestic economy. Secondly, fixed exchange rate regime helps to enhance the monetary autonomy of China's central bank at most of the conditions, and this role is more potent and robust at the long-end in the post-ciris era. Thirdly, the two channels through which global financial factors induce the spillovers of external monetary shocks, including changing financial portfolios by cross-border capital flows and the risk altitude of global investors, are of the similar importance. Particularly, the former channel has a slightly higher priority at the short-end, while the latter at the long-end. Finally, the comparison with New Zealand's experience provides some evidence that central banks are more likely facing a "monetary dilemma" as Rey(2013) suggested. Fixed exchange rate regime with capital controls might help to mitigate the external shocks in a turmoil period.

Our work has important policy implications for emerging countries. Kar and Spanjers (2014) assert that China is the leading source of illicit capital flows among developing countries, and it dominates the flows originating from Asia. Additionally, China has varied quite distinctly its exchange rate regimes before and after the GFC, which provides a unique case to study the monetary trilemma during the process of financial globalization and the spillover effect of UMP to EMEs.

This paper contributes to the literature by providing evidence on the international transmission of monetary policy from the largest emerging economy with an evolving financial system. Previous studies mainly explore the spillover of international monetary policy to advanced financial markets or small open economies (Hausmann *et al*., 1999, Frankel, 2004; Miniane and Rogers, 2007, Edwards and Rigobon, 2009). One of the few studies related to ours is Obstfeld (2015) who uses an error correction model to examine the extent of domestic interest rate independence from external shocks, for both short- and long-run interest rates, respectively, in relation to an exchange rate regime. However, Obstfeld does not consider the joint impact of exchange rate regime and capital control on monetary autonomy, neither the potential impacts of UMP on the international transmission. Edwards (2010, 2012) examines the effects of U.S. interest rate shocks on EMEs' domestic interest rates and considers the effectiveness of capital controls, but he excludes the countries adopting fixed exchange rate regimes and only focuses on the pre-crisis period. An additional distinguishing feature of our work is exploring the asymmetric response of domestic interest rates to foreign interest rates and other domestic variables by employing a non-linear ARDL model, recognizing that it is important to distinguish the spillovers of positive and negative changes of U.S. interest rates, as well as the asymmetric response to domestic fundamentals.

The rest of the paper is organized as follows: in section 2, we provide some institutional backgrounds about China's financial deepening and the monetary policy framework. We then offer the conceptual framework used for the analysis and provides a first look at the data in section 3. In section 4, we report the econometric methods and results. In section 5, we extend the analysis by investigating the role of capital controls in the international transmission of interest rate shocks. We make an international comparison in section 6 and conclude in section 7.

2. China's financial deepening and monetary policy framework

2.1 Financial deepening and globalization in China

China's financial markets have gone through significant deepening, reflected in the rapid expansion of credit to non-financial sectors. Credit to GDP ratios, widely used indicators of financial deepening, suggest that China's financial deepening has accelerating since 2008, recently surpassing levels of M2 to GDP ratio which is the main indicator for financial deepening in emerging EMs.

The maturing of China's financial system is reflected in the enhanced provision of banking services at the grassroots level. This can be supported by the rise in competition for banking services and greater financial inclusion. Bank accounts, bank branches, and ATMs have all strikingly been increasing in the last two decades. However, most importantly, increasing competitive pressures on China's commercial banking system have partially resulted in the sharp development of China's shadow banking system. Contrasting to the shadow banking systems in the US and European financial markets, off-balance credit activities is the main form of China's shadow banking. This is evident from the widening gap between total credit and bank loans since 2006 shown in Figure 1.

[Figure 1]

The development of domestic capital markets has also played an important role in financial deepening. The capitalization of bond markets has risen considerably in the 2000s, driven particularly by corporate and financial bond issuance (Figure 2). The equity market has also played an increasingly important role in the financial maturing of China. Total equity valuations have been quite volatile but have already surpassed the pre-crisis peak (Figure 3). This has also provided firms the opportunity to raise funds at more favorable prices and an alternative source of raising funds outside the banking and bond markets.

[Figure 2] [Figure 3]

2.2 Development of China's monetary policy framework

China's central bank, known as the PBC, has long been characterized by its multiple policy objectives including price stability, avoiding excessive currency valuation volatility, and promoting economy growth and employment. Previously the main tools of the PBC were the quantity-oriented measures including credit quota control and monetary aggregate targeting. Since the early of the 1990s, the PBC has endeared to make its manipulation measures towards more market-oriented way, mainly through establishing interbank markets and implementing open market operations that developed rapidly since 1996.

In order to protect the underdeveloped domestic commercial banks, China's interest rate system has kept a dual-track in the last two decades. One is the administrative policy rates directly determined by the PBC, including the required reserve ratio, benchmark deposit and lending rates[†]. As can be seen from Figure 4, these policy rates have been adjusted every time with the similar pace to keep a stable margin for banks' earnings. As for the required reserve ratio, it should be viewed as a quantity-oriented tool rather an interest rate tool because it can largely and directly impact the monetary aggregate in China. On the other hand, there is a market-based interest rate system, i.e., the interbank interest rates. The PBC aims to turn China's short-term interbank interest rates as the potential policy rate like the Federal Funds rates in U.S. The interbank markets appeared in the 1980s at various locations in China and were unified into a single market in 1996 with "Chibor" as its rates. The main interbank rates are interbank borrowing/offering rates with short maturities and bond repurchase interest

[†] The PBC removed the ceiling on lending rates at July 20th, 2013 and the ceiling on deposit rate at October 24th, 2015, which was viewed as the riskest step to free up China's interest rates. However, the PBC would continue to release the benchmark deposit and lending rates in the near future.

rates. The spot long-term interest rates in China mainly refers to long-term bond rates determined by the OTC bond markets in the interbank market[‡].

[Figure 4]

2.3 China's exchange rate regime and capital control

China's exchange rate regime has long been controversial over the past two decades. The RMB had been pegged against USD for eight years at 8.27-8.28 yuan/dollar till the PBC launched the exchange rate reform on July 21, 2005. The RMB was appreciated by 2.1% against USD on that day. This reform is widely viewed as a milestone, indicating China's exchange rate regime moving from de facto fixed exchange rate regime to a more flexible exchange rate arrangement. Since the reform in 2005, RMB had been appreciated against USD unilaterally by nearly 20 percent in the following three years, reaching 6.83 yuan/dollar in July 2008. As a response to the negative shock of GFC to the global economy and financial system, China's government pegged RMB against USD again from July 2008 to June 2010 without official announcements. Nevertheless, this reversion to fixed exchange rate regime should be viewed as a temporary reaction of China's government to stabilize the macroeconomy during a turmoil time. The RMB has been allowed to float again since July 2010. Rather appreciating unilaterally after the reform in 2005, the RMB value against USD began to fluctuate up and down in the last six years. This is partly due to the accumulated effects of the first floating period, as well as the loosened daily floating range of RMB in the interbank market, which has been increased by the PBC several times, from 0.5% to 1% in April 2012, and further to 2% in April 2014.

Align with the exchange rate regime switching in the past two decades, China's capital control on the external sector has been loosened accordingly, mainly for the transactions

[‡] There is a segmented bond trading market at stock exchanges, only available for individual investors since 1997. The trading volume at stock exchanges are relatively small and of little impacts and policy implications.

under the current account. Nevertheless, it still maintains a number of restrictions on capital accounts and places stringent regulations on cross-border capital flow when the RMB is under a consistently unilateral devaluation or appreciation pressure. Both inflows and outflows are targeted with different extents according to the timely economy and financial situation. When excessive capital inflows overheat the domestic economy and asset prices, capital controls on inflows would be tightened and outflows be encouraged. When there was a concern about massive outflows draining the domestic resources from ongoing projects or RMB value depreciated too fast, the capital control measures towards outflows were tightened. This is typical during the period in the second half of 2008 and 2016 when the concerns for China's economy crash were intensive. Despite any explicit change of official capital control policies, the PBC use its daily monitoring system to control the aggregate foreign currency convertible amount; and sometimes even use the "administrative window guidance" to restrict the daily scale of commercial banks for foreign currency transactions. Additionally, the State Administration of Foreign Exchange (SAFE), a subdivision of PBC, can use its national wide branches to monitor every foreign currency transaction for individuals and enterprises. SAFE sometimes contacts directly with the enterprises by telephone calls, requiring them to delay inward/outward remittance or reduce the scale of capital flows.

3. Interest rate differentials and the international spillovers of monetary policy

As Obstfeld (2015) pointed out, the most fundamental force driving the cross-border capital flows in the globally integrated financial markets is the direct interest rate linkage between countries. The classical covered interest-parity relationship reflects the results of constant arbitrage on the rates of return as the following form:

$$i_t = i_t^{US} + Ee_{t+1} - e_t + \rho_t \quad (1)$$

i_t and i_t^{US} are the short-term interest rate in China and US respectively. e_t is the nominal exchange rate and ρ_t is the currency risk premium. As can be seen from equation (1), the exchange rate flexibility against the central currency (for example, the United States) and the credibility of a countries currency would alter the international transmissions of direct interest rates.

Before the crisis, the conventional monetary policy taken by most of the central banks usually exerts impacts by manipulating a short-term interest rate directly and transmitting to interest rates at all maturity by term premium. As a result, the majority of previous literature examine the international pass-through of U.S. monetary policy by using the Federal Funds rate or the short-term market rate as the proxy of U.S. monetary policy. However, an interesting question is how changes of the long-term interest rate in the United States impact the other economy. According to Miyajima *et.al.* (2014), new Keynesian models tend to underestimate monetary spillover effects via the long-term rates for at least two reasons. The first one is that, even if the policy rate is assumed to be under the central bank's full control, long-term interest rates can fluctuate because of changes in the term premium triggered by capital flows to bond markets. The role of long-term interest rate in the international transmission of monetary policy will become more important since the global financial crisis. Gertler and Karadi (2013) confirm this by demonstrating that the Federal Reserve's unconventional monetary policy works mainly through the term premium and credit spreads.

In fact, the traditional literature about the international transmission of global monetary policy are essentially based on the covered interest rate parity, so the domestic interest rate is mainly focused on the short-term market rates. However, with the implementations of unconventional monetary policy after GFC, more and more researchers pay attentions to the possible downside effects of financial globalization, especially on the financial spillover

channels through more integrated global financial markets. Borio(2012), Bruno and Shin(2012) and Rey(2013) have pointed out that there is a global financial cycle that does not coincide with global monetary policy shifts and exchange rate changes alone do not fully offset its effects. Miyajima *et al.*(2014), Turner(2014), Obstfeld(2015) found long-term interest rates are more highly correlated across countries irrespective of the exchange rate regime. This is mainly because of the recent financial globalization. Yields in all bond markets integrated into the financial system tend to rise when US yields jump. Although the understanding so far of the comovement of global term premium is still limited, more and more evidence suggests that this comovement is related to investor risk aversion. Feroli *et al.*(2014) and Rey *et. al.* (2015) show that this channel has exhibited increasing importance with rapid expansion of bond arbitrageurs such as asset management companies, global banking institutions and US dollar asset traded worldwide.

Following Obstfeld (2015), we consider the relationship between long-term interest rates by combing the standard interest-parity based on the short-term arbitrage and the term premium. According to the simplest two-period model, domestic nominal risk-free long-term bond yield i_t^L will be dependent on an average of current and future expected short rates:

$$i_t^L = \frac{1}{2} i_t + \frac{1}{2} E_t i_{t+1} + \tau_t \qquad (2)$$

τ_t is the term premium that might reflect the covariance between future interest rates and a stochastic discount factor for domestic currency payments. Combining equation (1) and (2) shows that the long-term rates also obey an interest rate parity relationship, but with extra term premiums:

$$i_t^L = i_t^{US(L)} + \frac{1}{2}(E_t e_{t+1} - e_t) + \frac{1}{2}(E_t e_{t+2} - E_t e_{t+1}) + \frac{1}{2}\rho_t + \frac{1}{2} E_t \rho_{t+1} + \tau_t - \tau_t^{US} \qquad (3)$$

3.1 Interest rate differential: a first look at the data

The simplest way to examine whether the PBC owns a degree of monetary independence is to check the differential between domestic RMB yields and US dollar yields. The failure of cross-border arbitrage to equalize the onshore and offshore RMB yields would indicate some extent of monetary autonomy, either by the segmented financial markets or by capital controls.

Figure 5 shows domestic RMB yields and USD yields in four groups. The upper side presents the policy rates and short-term market rates in China and U.S. It seems that both China's policy rate and short-term market rate are not following the rates in the US closely. Does it means PBC owns a high degree of monetary autonomy? If we looked at the lower side which shows the data at the long end, the comovement since the GFC in 2008 is obvious. Specifically, China's long-run interest rate is more closely related to the term spread in U.S. despite the term spreads in both countries do not commove.

[Figure 5]

To view the interest rate differential better, Figure 6 reveals sizable and sustainable albeit time varying differentials between the RMB yields in China and the US dollar yields in the USA and the United Kingdom. Yield differentials, whether measured regarding policy rate or short-term market rates, have generally been 100 basis points or more in absolute level. The mean of these differentials in absolute level after the GFC is around 400 basis points, almost doubled compared to the mean before the GFC. However, it should be noticed that Federal Reserve decreased the short-term interest rate to nearly zero shortly after the GFC happened in 2008 and had complemented unconventional monetary policy since then for about eight years.

[Figure 6]

So we also plot the interest rate differential at the long-term end. The differential after the crisis has an obviously smaller volatility than that before the crisis. Is this evidence of the spillover effect of Fed's unconventional monetary policy to China's interest rate? As is known, the UMP of Federal Reserve, including quantitative easing and forward guidance, mainly works through lowering the long-term interest rate directly when the zero lower bond of nominal interest rate hits. And one of the international transmission channels of UMP is the signaling effect (Chen *et al.,* 2012; Bowman *et al.* 2015). Following Kamin (2016), we looked at the instant spillovers of UMP by event study approach. Figure 7 presents the one-day change of U.S. 10-year government bond yield in basis points with the two-day change of China's 10-year government bond yield after the 23 announcements of Feds between 2008 and 2013. It shows a decrease of US 10-year yield by 25 basis points induces a five bps decline on average in China's 10-year yield immediately after the announcement. However, It is interesting that the interest rate gap between 10-year government bond yields in China and US is almost smaller than the gaps for short-term market rates. Does this mean China's long-rate is more affected by external monetary shocks?

[Figure 7]

Nevertheless, this simple differential analysis cannot illustrate whether the change of gap is due to the transmission of external monetary shocks or other common factors, such as global financial forces or investor risk altitude. Meanwhile, examining whether domestic interest rate responds to domestic fundamentals is also important to assess the monetary independence.

3.2 Basic statistics and preliminary tests

We use monthly data for two samples spanning 1999M1-2007M3 and 2009M01-2016M12 named as pre-crisis and post-crisis separately. The data were obtained from CEIC and

Bloomberg database. The period is chosen for the need to exclude periods of exceptional market volatility and to balance the number of monthly observations between two sample periods. Meanwhile, during the whole time span the exchange rate regimes of China had experienced several rounds of reforms. This provides us a good opportunity to examine the role of exchange rate regime on monetary independence within one country and expel the potential impact of diverse political and cultural backgrounds based on panel data. Before July 21, 2005, the RMB was strictly pegged to US dollar. Then the RMB was allowed to float in a narrow margin. However, the pegged exchange rate was reinstituted unofficially when the global financial crisis hit. After 're-pegging' around two years till June 2010, the RMB has now moved to a managed floating exchange rate with enhanced daily volatility range. It is worth noting that we use the average monthly data so that the effect of different trading time between China and US on the spillover analysis can be minimized, especially when we focus on the long-run relationship in equilibrium.

Table 1 presents the basic statistics for the interest rates with different maturities in China and U.S. in the two sub-periods. As can be seen, the interest rates in the US were higher than those in China before the crisis, irrespective of any kinds of interest rates considered in the study. On the converse, China's rates are all higher than U.S. after the crisis. The interest rate differential at the short-end was the smallest among all three cases before the crisis, while the differential at the long-end is the smallest after the crisis.

[Table 1]

Table 2 contains the data on unit root test for the policy rates, short-term and long-term rates before and after the GFC respectively. The results show that some of the interest rates are stationary in the sub-period, while others are non-stationary. Anyway, the difference of all these variables is stationary. The mixed feature of the statistics imposes a challenge of testing

the co-integration between China and US interest rates with the standard two-step or error correction estimation methods.

[Table 2]

4. Econometric methods and results

4. 1 Methodology

One way of examining whether PBC owns monetary autonomy is to check whether there is a co-integration or stable long-run relationship between domestic and U.S. interest rate given other related variables taken into account. Given the mixed statistical features of the variables in two sample periods, one proper method is to estimate an error correction model as the equation (1) based on the approach of Pesaran, Shin and Smith (2001) (hereafter PSS). The PSS method can test the co-integration even when the data set contains both the stationary and non-stationary time series, which matches our data well. A computed F_{PSS} test will give the information whether the long-run relationship exists between domestic interest rate, U.S. interest rate and other control variables (X).

$$\Delta i_t = \sum_{p=1}^{P} \rho_p \, \Delta i_{t-p} + \sum_{q=0}^{Q} \beta_q \, \Delta i^*_{t-q} + \sum_{s=0}^{S} \gamma_s \, \Delta X_{t-s} + \theta(i_{t-1} - \xi i^*_{t-1} - \omega' X_{t-1}) + u_t \quad (4)$$

If the co-integration exists, ξ is the long-run relationship between China and U.S. interest rate, and $-\theta$ is the adjustment speed towards that relationship. According to the standard open economy macro model, $\xi = 1$ and $\omega = 0$ mean the home currency is under a fully credible currency peg and fully interest rate pass-through. With some exchange rate flexibility, however, there would be less than full pass-through of the base rate to the domestic rate, i.e., $\xi < 1$ and the domestic interest rate might respond to domestic variables or other international variables included in the vector X. For example, through the Taylor rule mechanism, home country interest rate would respond to domestic inflation and the output gap, as well as other related variables. So whether the co-integration exists and the

information about the magnitude of ξ and the statistical significance of the coefficient vector ω are informative about the degree of China's monetary autonomy.

In the benchmark estimation for equation (4), X include China's inflation and output gap, as well as the devaluation expectation of China's currency, which is the basic story line in an open macroeconomy model. To reflect the impact of global financial cycle through changing the global risk tolerance or financial portfolios by international capital flows, we also consider the regressions with additional variables in X.

The inflation gap is calculated based on consumer price index in China. As GDP data is not available on a monthly basis, we choose value added of the industry (VAI) to proxy the output in China. VAI is one of the main monthly indicators monitored by PBC to track the momentum of China's macro economy. When calculating expectation of RMB devaluation (ExpDev), we use the one-year non-deliverable forward rate in Hong Kong offshore RMB market to proxy the expectation of RMB exchange rate among the market participants, including both domestic main commercial banks and overseas investors. Following several researchers, including Bruno and Shin (2013), Rey (2013) and Obstfeld (2015), we use the Chicago Board Options Exchange's equity option volatility index (VIX) as the useful proxy for the state of the financial cycle. A lower value in VIX means a greater tolerance for risk-taking or an increase in leverage. The global financial factors can influence the international transmission by two opposite ways. If the factor takes effects as a common global factor, the estimation for ξ would be reduced when VIX is included in the regression. However, if the global financial factor impacts domestic interest rate by shifting the cross-border capital flow, the estimate of ξ would be increased compared with the level without VIX.

To gauge the additional impact of exchange rate regime on the monetary independence, we use the interactive specification as following:

$$\xi = \xi_0 + \xi_1 \times PEG \quad (5)$$

Where PEG is an indicator variable. We define PEG as one during the periods (1999M01-2005M07, 2008M07-2010M06) when RMB was pegged strictly against U.S. dollars. Otherwise, it is zero.

The above benchmark model, along with the majority of the studies exploring the spillover effects of international monetary policy (Obstfeld, 2015, Miyajima, Mohanty and Yetman, 2014), adheres to a linear paradigm, reflecting the assumption that increase and decrease of international interest rate have symmetrical effects on domestic interest rates. However, there is some reason to believe that domestic central bank should not respond to Federal Reserve in such a simplistic fashion. Considering a hike of Federal Reserve target rate, the international capital flow might come back to U.S. from emerging markets, which would bring financial vulnerability to emerging economies when the capital outflow is huge and constant. Further, the hike or cut of international interest rate usually reflects the different macro-economy outlook for the U.S. So the domestic central bank might have different attitudes towards the hike or cut of international interest rates. Except for the potential asymmetric response to international interest rates, China's central bank might also have an asymmetric response to domestic variables. For example, China's government is known for a preference to stimulate the economy and smaller tolerance to the cyclical downturns (Chen, *et. al.*, 2016; Liu, *et. al.*, 2009).

In response to these issues, we apply the non-linear ARDL (NARDL) technique developed by Shin *et al.* (2014) to analyse the possible asymmetric relationship between China's interest rate and U.S. interest rate as well as other domestic and global factors. The NARDL method also allows us to examine simultaneously both the long-run and short-run nonlinearities in the relationship. The whole estimation process can be decomposed into the following three steps.

Firstly, we estimate the unrestricted NARDL model in equation (6), which allows the asymmetric response to all of the variables. Similarly, the bound test FPSS statistics can tell whether the cointegration exists. Secondly, we use the Wald test to see if the assumed asymmetric response is significant. Finally, we estimate the model by only allowing significantly asymmetric terms so as to obtain more efficient estimates. It is worth noting that the symmetric ARDL is essentially the most restricted NARDL model without any significant asymmetric properties. Based on the process, we could consider all the possibility of the asymmetric response, and not rule out any symmetric case.

$$\Delta i_t = \theta\left(i_{t-1} - \xi^{+} i_{t-1}^{*+} - \xi^{-} i_{t-1}^{*-} - \omega^{+'} X_{t-1}^{+} - \omega^{-'} X_{t-1}^{-}\right) + \sum_{p=1}^{P} \rho_p \, \Delta i_{t-p} +$$

$$\sum_{q=0}^{Q}(\beta_q^{+} \Delta i_{t-q}^{*+} + \beta_q^{-} \Delta i_{t-q}^{*-}) + \sum_{s=0}^{S}(\gamma_s^{+'} \Delta X_{t-s}^{+} + \gamma_s^{-'} \Delta X_{t-s}^{-}) + u_t \quad (6)$$

Where the U.S. interest rate and other control variables are decomposed into the sum of negative and positive changes. Specifically, the variable x_t is defined as $x_t = x_0 + x_t^{+} + x_t^{-}$, where x_t^{+} and x_t^{-} are partial sum process around a threshold of zero:

$$x_t^{+} = \sum_{j=1}^{t} \Delta x_j^{+} = \sum_{j=1}^{t} \max(\Delta x_j \ , 0) \, , \ x_t^{-} = \sum_{j=1}^{t} \Delta x_j^{-} = \sum_{j=1}^{t} \min(\Delta x_j \ , 0) \quad (7)$$

The following charts show the decomposition of US policy rate, short-term rates and long-term rate respectively.

[Figure 8]

4.2 Spillovers of benchmark policy rate from U.S. to China

As China's policy rate is determined directly by administrative announcements of the People's Bank of China (PBC), unlike the EFFR determined by open market operations of the Federal Reserve, China's policy rate reflects the policy stance of PBC directly. Although the policy rate is determined administratively, it does change with time. In fact, China’s policy rate is more like an important signal of the monetary stance of PBC, through which PBC aims to transfer its policy goals to the market rate and public expectations. So we firstly explore

whether the PBC, China's central bank, reacts directly to Fed's actions by adjusting its policy rates.

The saving deposit rate and lending rate are the benchmark policy rates of PBC. Meanwhile, the policy rates with different maturities are usually adjusted by PBC simultaneously to keep a same or similar term premium. Since the effective federal funds rate is a short-term rate, the deposit rate with three months maturity (DR3M) is chosen as China policy rate. To save space, we only present the regressions based on the final step. Table 3 shows the estimation results for China's policy rate.

[Table 3]

Before the crisis, there is no significant asymmetric effect for all of the explanatory variables according to the Wald test. The unrestricted NARDL model is reduced to the symmetric ARDL model. The coefficient of US policy rate is nearly zero, and it is increased slightly to 0.015 when VIX is included. However, both of these two coefficients are not significantly different with zero. Fixed exchange rate regime increase the spillover of EFFR marginally, but also insignificantly. Despite that China's policy rate responds to output gap and currency valuation expectation significantly in the equation in column (1), it does not react significantly to these domestic variables when VIX is included. In summary, although there is little spillover effects of US policy rate, China's policy rate was impacted obviously by global financial factors and did not response to domestic variables significantly.

After the crisis, China's policy rate begun to respond to domestic variables significantly and asymmetrically, showing an obvious preference of lower tolerance to the economy slowdown. Although the response to inflation gap is positive, it is not big enough (less than one) according to Taylor Rule (1993), leaving room for the inflation to be self-filling. Meanwhile, the benchmark policy rate only responds to negative output gap in a

countercyclical way. Regarding to the response of China's policy rate to EFFR, it is also significantly asymmetric. The coefficient of positive change of EFFR is huge, reaching 7.37, while the coefficient of negative change is negative 19.6. These numbers are largely higher than the theory expected, which might be caused by the well-known "zero lower bound" environment after the crisis.

As the effective federal fund rate was decreased from around five percent at the end of September 2007 to nearly zero in the middle of December 2008, it has been kept around the zero lower bound for almost seven years till December 15, 2015 when the Federal reserve begun to increase the federal rate gradually. The Federal Reserve has implemented the unconventional monetary policy (UMP) during the zero lower bound period to stabilize the financial system and recover the economy. Two typical UMP tools, including quantitative easing and forward guidance, have been used. The quantitative easing policy mainly worked through lowering the long-term interest rate directly and the forward guidance worked indirectly by shaping public expectations to a desired policy path in the future. A number of studies (Edwards, 2012; Chen, *et. al.*, 2012, Rogers, *et. al.*, 2014) used the term spread between ten-year and three-month treasury yield as the indicator of the Federal Reserve's monetary policy. The term spread is a good indicator of UMP esepecially when the Federal Reserve decided to "twist" the yield curve by buying long term securities, while selling short term securities simutaneously from September 2011 for two years. So we use the term spread as the proxy for the U.S. monetary policy after the crisis, and the estimation results are presented in Table 4.

[Table 4]

As can be seen from the table, one percent decrease of U.S. term spread would induce more than a half percent hike of China's policy rate. Although the coefficients of term spread

are not statistically significant, the coefficients of the cross term of PEG and term spread is negative at the ten percent significant level, reaching 0.5 in both columns of the table 4. This indicates that there was very limited spillover effect of UMP to China's policy rate, especially when the RMB had been pegged against US dollars during the post-crisis period. Although the response of China's policy rate to inflation gap is not significant, China's PBC still has some extent of monetary autonomy since it shows an obvious tendency to stimulate the economy even beyond the potential GDP growth.

4.3 Spillovers of short-term rates from U.S. to China

To explore whether China's short-term market rates can avoid the external shock from U.S. monetary policy, we choose 3-month Treasury bill yields as the short-term interest rates for both countries. The data is from DataStream. As China's 3-month Treasury bill is not available before 2006 and has not been traded actively till now, DataStream calculates the average interbank interest rates to proxy China's short-term government bond rate. As we discussed before, although China's short-term interest rates have become more market-oriented, they are intervened deeply by the open market operations conducted by the PBC in the interbank markets to play a role of the potential policy rates. Table 5 presents the estimation results.

[Table 5]

Panel A shows the results in the pre-crisis era. According to the column (1) and (2), there is no significant spillover effect from U.S. to China no matter the global financial factor is considered or not. The interaction term of PEG and U.S. rate is significantly negative, indicating a marginally decreasing effect from fixed exchange rate to external shocks. On the other hand, China's interbank rates did significantly respond to inflation gap, despite no significant respond to output gap and expectation of currency valuation change. Moreover,

when we include the benchmark interest rate in the regression, the column (3) shows that there is a significant and huge transmission from the policy rate to the interbank short-term market rate. In conclusion, China's interbank market rates are mainly determined by domestic policy rate and not significantly impacted by the external interest rate shocks.

According to panel B, China's short-term rate is impacted by the U.S. monetary policy significantly after the crisis, but only by the positive change of the term spread. One percent hike of U.S. term spread would lead to more than two percent increase of China's short term rate. Considering the fact that the change of the term spread was mostly negative in the post-crisis era, the results indicate that China's interbank market rates were more impacted by the surprised action of the Federal Reserve or the exit of the UMP. The spillover effect of the positive change of external interest rate change is slightly increased when the global financial factor is considered, which indicate that the two channels through which VIX takes effect, including changing portfolio by capital flows and impacting the risk altitudes of global investors, have the similar importance for the international transmission of interest rate shocks.

Nevertheless, when the benchmark policy rate is taken into account in the post-crisis era, the estimation of the positive change of U.S. term spread is decreased by nearly a quarter, reaching 1.6, while the coefficient of domestic policy rate is around 0.8. Pegging the RMB against USD could decrease the international spillovers by 77%, down to 0.36. Moreover, the interbank short term rate significantly responds to domestic inflation and also to the negative output gap positively as the policy rate shown in table 4.

In conclusion, although there is a consistent transmission of policy stance from the benchmark policy rate to the interbank market rate, the positive change of U.S. term spread can still have a very big spillover effect when the RMB is allowed to float.

4.3 Long-term interest rate and the cross-border spillovers of monetary policy

Although PBC owns some extent of monetary autonomy at the short-term end, how is it at the long-term end? Can the domestic monetary stance be transmitted to the long-end? If the long-term rates are strongly subject to global forces, the power of short-term rates to steer the economy could diminish.

We now turn to estimate equation (5) and (6) for the long-term interest rates by choosing ten-year government bond yields as both countries' indicators. As China's 10-year government bond rate is only available from the year of 2002, the pre-sample size is too small to use the bound test. Therefore, we compare the results after the crisis with the results in the whole sample to explore the potential difference since the GFC. Table 6 shows the results.

[Table 6]

According to Table 6, China's long-term interest rate exhibits obviously asymmetric reactions not only to U.S. interest rate but also to the domestic output gap, just like the short-term rate does. The spillover of positive change of U.S. long-term rate has a nearly full pass-through to China's long-run interest rate, while the negative change of US long-term rate has no spillover effects to China. When the RMB is fixed, the pass-through from U.S. long-term rate would decreased by 70 percent. These findings hold during the whole sample as well as in the post-crisis era. Except the fact that the surprise of central bank behaviour usually exerts a bigger impact on markets, the asymmetric response of China's long-term interest rate might also reflect the investors' expectation on China's government's ability and preference to stimulate China's economy by domestic demand when the growth of US economy slows down.

Comparing the results in two panels of Table 6, it appears that the spillover of positive change of U.S. long-term interest rate even holds before the crisis since the coefficients of US interest rates in the whole sample is significantly positive and larger than that in the post-crisis era. Further, for the results in the same estimation period, we find that the spillover effect of positive change of U.S. ten-year government bond yield on China's ten-year government bond rate is decreased when VIX is included, and with a smaller gap in the post-crisis era. This indicates that the global financial factor works in the international transmission at the long end more like a common global factor reflecting the risk-taking tolerance of investors, but the role of changing portfolio by capital flows expanded after the crisis.

Different with the short-term rate, there is no efficient transmission from domestic benchmark policy rate to the long-term rate. The coefficient of benchmark policy rate is negative during the whole sample period, and not significantly different with zero in the post-crisis era. Moreover, unlike the significant reaction to inflation gap of China's short-term rates, China's long-term interest rate does not respond to inflation gap significantly after the crisis. Regarding to the response to output gap, it is asymmetrical and only significantly positive to the negative output gap both in the whole sample and post-crisis era. The coefficients of positive output gap changes are negatively around 0.1, while the coefficients of negative output gap changes are positively around 0.2. These results suggested that China's government's preference on promoting growth could be transferred from short-term policy rate to long-rate, but the concern about inflation control are not transmitted to the long-end effectively.

Another interesting finding is about the role of fixed exchange rate regime on the monetary independence. Pegging the RMB against USD can significantly reduce the spillover effect of U.S. interest rate shocks when VIX is included during the whole sample period, while the

role of pegs become more potent after the crisis no matter VIX is considered or not. This change might be explained by the fact that Federal Reserve's unconventional monetary policy works mainly through the term premium and credit spreads (Gertler and Karadi, 2013), and the rapid expansion of global bond markets including China's domestic bond markets in the last decade. We will discuss further the role of exchange rate regime and capital control in the international spillover of monetary policy in the next section.

In summary, although pegging RMB against the USD helps to reduce the spillover of US monetary shocks, the international transmission of US to China at the long-end is still significant. Meanwhile, the monetary stance steered by the adjustment of policy rates cannot induce a consistent and efficient transition into the long-end.

5. Role of exchange rate regime and capital control

An interesting question from a policy point of view is whether flexible exchange rate and capital controls can help to avoid or reduce the international transmission of external monetary policy shocks. This issue has been addressed by a vast academic literature and attracted a renewed interest after the recent global financial crisis. Almost all the studies (Broda, 2004, Shambaugh, J.C., 2004, Prasad et al., 2005, Chang et al. 2015, Obstfeld, 2015) suggested that flexible exchange rate regime would benefit for increasing the monetary independence. For the capacity of capital controls, the majority of the literature, no matter undertaking the cross-country survey or focusing on the case study of specific countries, find essentially no evidence that capital controls are effective to isolate emerging countries from external interest rate shocks (Edwards (1999), De Gregorio *et al.* (2000), Eichengreen (2002) and Miniane and Rogers (2007)). However, some case studies did show that capital controls were effective as a buffer to external shocks. For example, Kaplan and Rodrik (2001) and Edison and Reihart (2001) found capital controls in Malaysia intended to enhance the policy

independence. Edwards(2010) suggested that stricter restrictions on cross-border capital flows in some Asian countries help to mitigate the external monetary shocks. However, there is still no consensus on the effectiveness of capital controls.

According to our findings in the previous section, fixed exchange rate regime helps to enhance the monetary autonomy of China's central bank at most of the conditions, and this role is more potent and robust at the long-end in the post-ciris era. Why is it so? We argue that the following three factors will contribute to explain our findings.

The first is related with the financial globalization. Some recent studies suggest that flexible exchange rate would amplify the spillover of external monetary shocks. Rey (2013) pointed out financial globalization has led the central banks facing a "dilemma not trilemma" when the risk-taking channel is an important driver of credit growth, which means that without capital control, the independence of monetary policy cannot be achieved even with a flexible exchange rate.

Secondly, our findings that fixed exchange rate helps to reduce the spillover from external shocks more robustly and significantly via the long-term bond interest rate channel, especially in the post-crisis era, is consistent with recent studies on the role of long-term interest rates in the spillover of US monetary policy. Gertler and Karadi (2013) pointed out that Federal Reserve's unconventional monetary policy works mainly through the term premium and credit spreads. Miyajima *et al.* (2014) and Obstfeld (2015) confirmed the role of long-term interest rate in the international transmission of monetary policy via global bond markets. Therefore, fixed exchange rate can decrease the spillovers of external interest rate shocks particularly at the long-end by stabilizing the risk and term premium well, which is less important for the spillovers at the short-end.

The third is involved China's arrangement of capital controls and exchange rate regime and the possible effectiveness of capital controls for isolating from external shocks. China's government kept a pegged exchange rate regime not only by interventions in the foreign currency market but also by capital controls.

To explore further the role of capital control in the international transmission of US monetary policy to China, especially in the post-crisis, we construct a de jure monthly index to reflect the extent of China's control on capital flows. The index is calculated by scoring the 43 sub-items in the 12 categories under the capital account based on the method of Jin (2004) and Gou *et al.* (2012). A higher value in the index indicates more stringent controls on cross-border capital flows. As can be seen from Figure 9, our index is mostly consistent with the Chen and Qian (2016) index. Despite a general loosening trend for China's capital controls in the last two decades, the control policies, even the de jure measures, were usually strengthened when the RMB was under the devaluation pressure, especially during the financial crisis. During the period of the Southeast Asia financial crisis in 1998~1999 and the global financial crisis in 2008~2009, China's official capital controls were obviously tightened to avoid the negative shocks by potential capital flights.

[Figure 9]

We then empirically examine the impacts of capital controls in the transmission of monetary policy by including the interaction term of capital control index and the U.S. interest rates. Table 7 presents the results. Panel A shows the results for the transmission at the short-end and Panel B reports the results at the long-end. As can be seen from the table, most of the results are robust with the Panel B of Table 5 and 6. The positive change of U.S. monetary policy still has significant and full pass-through to China when the RMB was not pegged against the US dollar. The coefficients of the interaction terms of capital control and

US interest rate are negative, which means tightened capital controls help to decrease the spillovers of the external monetary policy shocks. However, these coefficients are not significant when the role of fixed exchange rate is taken into account.

[Table 7]

The above findings seems to support that fixed exchange rate regime is more effective to improve the monetary independence than capital control. However, as we noted before, China's pegging currency is usually combined with the complementation of capital controls, especially with the implicit and administrative measures which can not be reflected in the de jure index. Subject to the limitation of the data for a more precise index of capital mobility, the entire effects of capital controls might be confounded with the other policy objectives. For example, the coefficient of PEG could include some effect of capital controls. Nevertheless, the results in Table 7 appears to suggest that the combined arrangement of pegs and capital control during the crisis period is helpful to avoid the external shocks by limiting the cross-border capital flows and stabilizing the term premium. These are consistent with some previous research. As Munro (2014) suggested, currency premiums are usually lower in countries intervening in the foreign currency markets than those do not. Ma and McCauley(2008) pointed out that China’s capital controls bound sufficiently to offer policy makers some degree of monetary autonomy under a de facto dollar peg.

In conclusion, pegging currency against USD and strengthening capital controls is especially useful to improve domestic monetary independence during the crisis period by reducing the term and currency premiums or/and the global credit flow. However, these benefits also bring some downside effects. The capital control measures tend to accumulate the bond risk premium despite lowering the currency risk premium, which needs to be balanced by the government.

6. International comparison

To put China's experience in context, we also consider the international transmission of external interest rate shocks from U.S. to New Zealand. As is well known, New Zealand is the first country to adopt inflation targeting and probably has the most clearly defined target and policy framework. Meanwhile, New Zealand, as one of the developed countries, also has adopted the floating exchange rate regime almost without capital controls, at least during the period from 1999 to 2016. These provides us a good case to explore the role of regime arrangements on the monetary autonomy by comparing the results between China and New Zealand.

Although the Reserve Bank of New Zealand(RBNZ) states the inflation as its main targets, it might respond to output gap when setting its policy rate. As Huang et. al. (2001) pointed out, Taylor rule is still a good way to capture the behaviour of RBNZ. Huang (2002) further provided some evidence that RBNZ's monetary policy pattern is "even more Fed-like" since the Official Cash Rate regime has been adopted in 1999. Recently, Kendall and Ng(2013) updated the Taylor rule of RBNZ for the post-crisis period, and found no significant difference for the conducts of monetary policy in New Zealand, Australia and the U.S. However, all of these studies about New Zealand focused on estimating Taylor rule in a closed-economy model rather the impacts of external monetary policy on RBNZ's decision. But their findings do suggest that RBNZ could also respond to output gap as a concern for economic welfare to maintain the price stability. So we estimate the international spillover of U.S. interest rate shocks just as we did for China. The only difference is that there is no need to consider the role of fixed exchange rate and capital controls. We also starts the estimation process from unrestricted NARDL and let the data choose the final model specification.

The data period covers from 1999 to 2016, and is divided into two sub-periods, i.e., the pre-crisis period and post-crisis period as we defined before. The inflation target is chosen

according to the relevant Policy Target Agreement in each period. In line with Huang(2002), RBNZ(2007), Kendall and Ng(2013), we estimate the output gap as the percentage deviation of real GDP from HP filter trend. The currency devaluation is defined by the percentage change of the difference between the one-year ahead expectation of New Zealand Dollar(NZD) against USD and the actual exchange rate at the time. All of the data are from the RBNZ. As only the quarterly data for inflation, the real GDP and the expectation of currency valuation are available, we transform them into monthly data by linear interpolation method.

Four interest rates in New Zealand are considered. Firstly, we explore how the basic policy rate (OCR) is impacted by the U.S. monetary policy. Then, floating first mortgage interest rate is examined as it is one of the main monitoring indicators of RBNZ. Considering the importance of the housing markets to New Zealand's economy and financial stability, we then explore the possible spillovers of external monetary shocks on New Zealand's two-year fixed mortgage interest rate. Finally, we consider the international transmission at the long-end by using the ten-year government bond yield.

Table 8 reports the results for the spillover effects from the Federal Reserve to RBNZ's policy rate. The final specification is reduced to symmetric ARDL model according to Wald test. As can be seen from Panel A of the table, one percent hike of Federal Reserve Fund rate could increase OCR by nearly 0.3 percent significantly. RBNZ did exhibit a priority of responding to inflation gap than to output gap. During the post-crisis era, one percent hike of the U.S. term spread could induce an increase of OCR by nearly 0.5 percent at 1% significant level. When VIX is included, the spillover effect is increased to 0.6 percent. And the coefficients of inflation gap and output gap are all significantly negative. These means that the policy rate is too loose based on the Taylor Rule, which is consistent with the findings of

Kendall and Ng(2013). In conclusion, OCR became more susceptible to external monetary shocks after the crisis.

Table 9 shows the results for the floating first mortgage interest rate. According to the column (1) and (2), 50 basis points hike of U.S. policy rate only induced about 6 bps increase of NZ's floating mortgage rate before the crisis. And the floating mortgage rate, as an important short-term market rate, did respond significantly to domestic inflation gap and output gap. However, when we include the OCR in the regression as shown in column (3) and (4), the spillover effect from U.S. became not significantly different with zero. Meanwhile, the response to domestic inflation gap and output gap also decreased to nearly zero. The coefficients of OCR are around 0.95, which means there is a nearly full transmission from benchmark policy rate to short-term market rate before the crisis. Nevertheless, the transmission from OCR became smaller in the post-crisis era, declining to 0.78.

Table 10 presents the results for two-year fixed mortgage interest rate. As can be seen from Panel A of the table, the spillover effects from external interest rate shocks are much bigger than those for the floating mortgage rate. 50 bps increase of U.S. long-term rate could induce about 33 bps hike of NZ's two-year mortgage rate. Even when the OCR is included in the regression, the spillover effect is still significant and obvious. About a half of external interest rate change can be transmitted to the middle-term retail rate in New Zealand. And the coefficients of OCR are decreased to 0.3, less than one third of the value for the floating mortgage rate. After the crisis, the spillover effects from U.S. monetary policy are similar with those before the crisis. However, the coefficients of OCR are insignificant while the response to the expectation of NZD devaluation becomes significantly positive. As shown in the column (7) and (8), like the OCR, the spillovers are also increased when the global financial factor is included, but with a much smaller increment. This indicates that the

expectation of market participants do play a more important role in the middle-term. In summary, the two-year mortgage interest rate of New Zealand has been strongly impacted by U.S. long-term interest rate even before the crisis, and the domestic monetary stance could not be transmitted consistently and effectively to the middle-term retail rates after the crisis.

The results at the long-end are presented in Table 11. Before the crisis, there is no co-integration based on the equation (4) according to the bound test. However, the co-integration between New Zealand's long term rate and U.S. long term rate exists at the 1% significant level. 50 basis points hike of the U.S. ten-year government bond yield can induce about 75 bps increase of New Zealand's ten-year yield. The coefficients of U.S. long-term rate are slightly decreased if the global financial factor VIX is included. The coefficient of OCR is not significant, indicating that no efficient transmission from the domestic policy rate to the long-end.

Comparing NZ's experience with China's case, the main similarity is that although the domestic central bank can own some autonomy at the policy rate setting and consistently transmit its monetary stance to the short-term market rate, the key interest rate impacting the real economy, i.e., the long-term interest rate, is largely impacted by the external monetary policy. The other common pattern is that the spillover effects become more significant and potent in the post-crisis era. However, only the positive change of U.S. long-term interest rate can produce a significant transmission to China's domestic interest rate, while there is no asymmetric response of New Zealand's interest rate to external monetary shocks. This might be explained by the different size of the economy and growth model in these two countries. Meanwhile, the spillover effect at the long-end in the post-crisis era for China's case is 70 percent less than that for New Zealand when the RMB was pegged against the USD, indicating fixed exchange rate alien with capital controls during the turmoil period could help to avoid the international spillovers of external monetary shocks.

7. Conclusion

In this paper, we examine whether there are spillovers from U.S. monetary policy to China's domestic interest rates, including police rate, short-term and long-term rates. Especially, we focus on the role of long-term interest rate and exchange rate regimes in the international transmission under the background of financial globalization and the spillovers of the unconventional monetary policy.

Our first finding suggest that although the PBC owns some extent of autonomy since it does respond to domestic variables significantly, the spillover effects of U.S. monetary policy are significant and strong to China’s policy rate and short-term rates after the crisis, which provides the evidence for the international transmission of UMP. Further, this spillover effect at the long-end even holds before the crisis, but only for the positive change of U.S. long-term interest rate. This might reflect the expectations of investors on China's government's ability and preference to stimulate the economy by expanding domestic demand when facing a slowdown of U.S. economy. Our results about the spillover effect of UMP to China's interest rates are consistent with the previous research. Miyajima et al.(2014) and Obstfeld(2014) confirm that unconventional monetary policy in the United States and other advanced economies has been increasingly transmitted to Asia. Financial globalization reduces the control of domestic monetary authorities over interest rates. However, this is not because of the failure to control the price of bank reserves, but rather because of difficulties in controlling long-term interest rates that ultimately determine the real economy activities. Nevertheless, movements in the US long-term interest rate also reflects the non-US factors, such as the "global saving glut." We did not identify the specific source of shock to US long-term rates.

Secondly, the PBC has a stronger reaction to domestic variables after the crisis for the benchmark policy rate and the short-term market rates. The significantly positive response to

inflation gap and the asymmetric response to output gap reveals the preference of the PBC on inflation control and stimulating economy, even beyond the potential growth rate. However, the monetary stance towards inflation cannot be transmitted to the long-end consistently.

Thirdly, the two channels through which global financial factors take effects in the international transmission of monetary policy, i.e., changing financial portfolios by cross-border capital flows and impacting the risk tolerance of global investors, have the similar importance. Particularly, the former channel has a slightly higher priority at the short-end, while the latter at the long-end.

Finally, fixed exchange rate regime helps to enhance the monetary autonomy of China's central bank at most of the conditions, and this role is more potent and robust at the long-end in the post-ciris era. We explain this by three factors. The first is the so-called "dilemma" under financial globalization; the second is that the unconventional monetary policy works mainly through the term premium and credit spreads via global bond markets. The last is the fact that China's PBC achieved the de facto fixed exchange rate with capital controls not only by huge interventions in foreign currency markets but also by capital controls, including both explicit and implicit measures.

The comparison with New Zealand's experience provides some evidence that central banks are more likely facing a "monetary dilemma" as Rey(2013) suggested. But These results do not suggest that fixed exchange rate regime and capital controls are either good or bad arrangements for China, but instead add to the knowledge about the influence of the Fed on other nations, and the challenges that an economy will face when it fixes its exchange rate. The costs from capital controls and pegged exchange rate are likely to increase as the domestic financial markets become more integrated with the global ones. Persistent interventions to resist currency appreciation or depreciation, financed by the issuance of

short-term government and central bank securities, also involves risks. However, these arrangements might help to mitigate the external shocks in a turmoil period.

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Figure 1. China's credit expansion and broad money

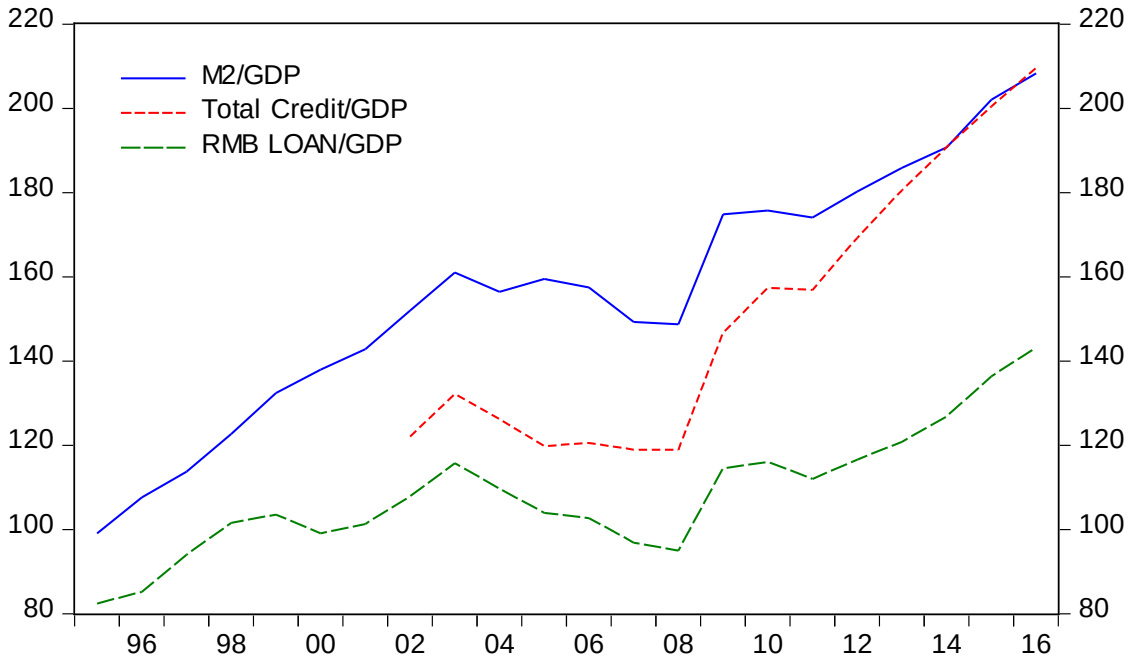


Figure 2. Issuance of China's bond markets

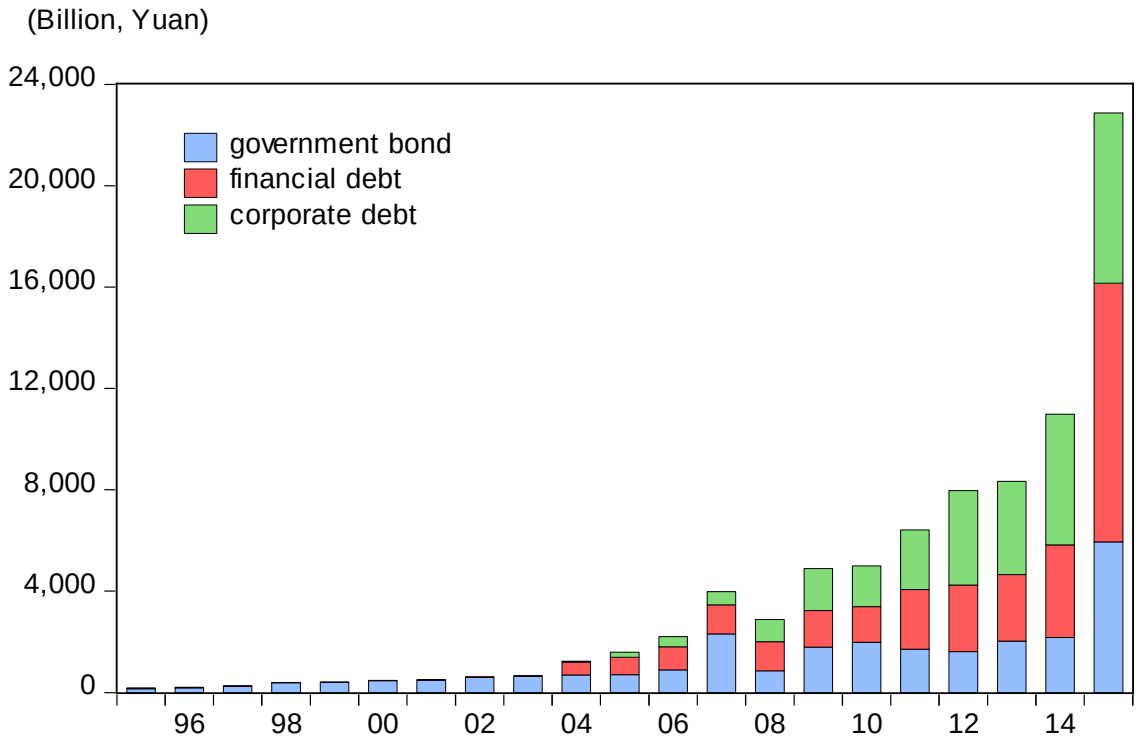


Figure 3. Equity market capitalisation

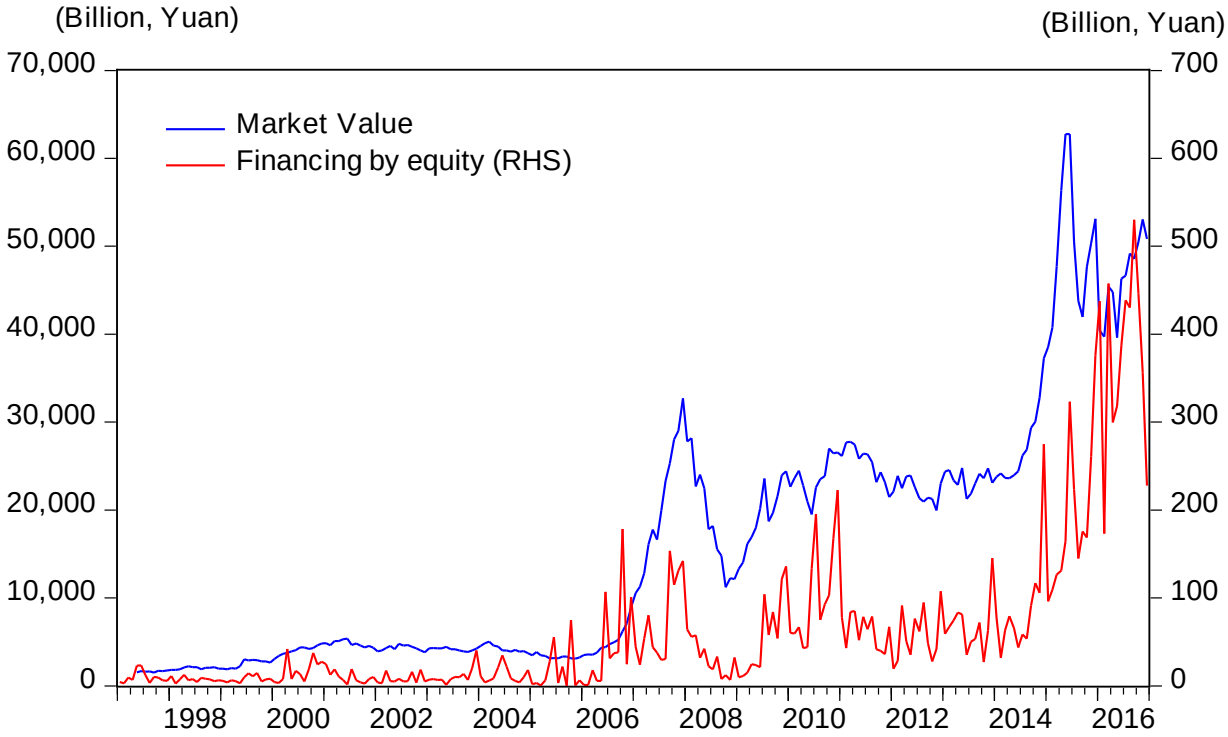


Figure 4. China’s policy interest rate

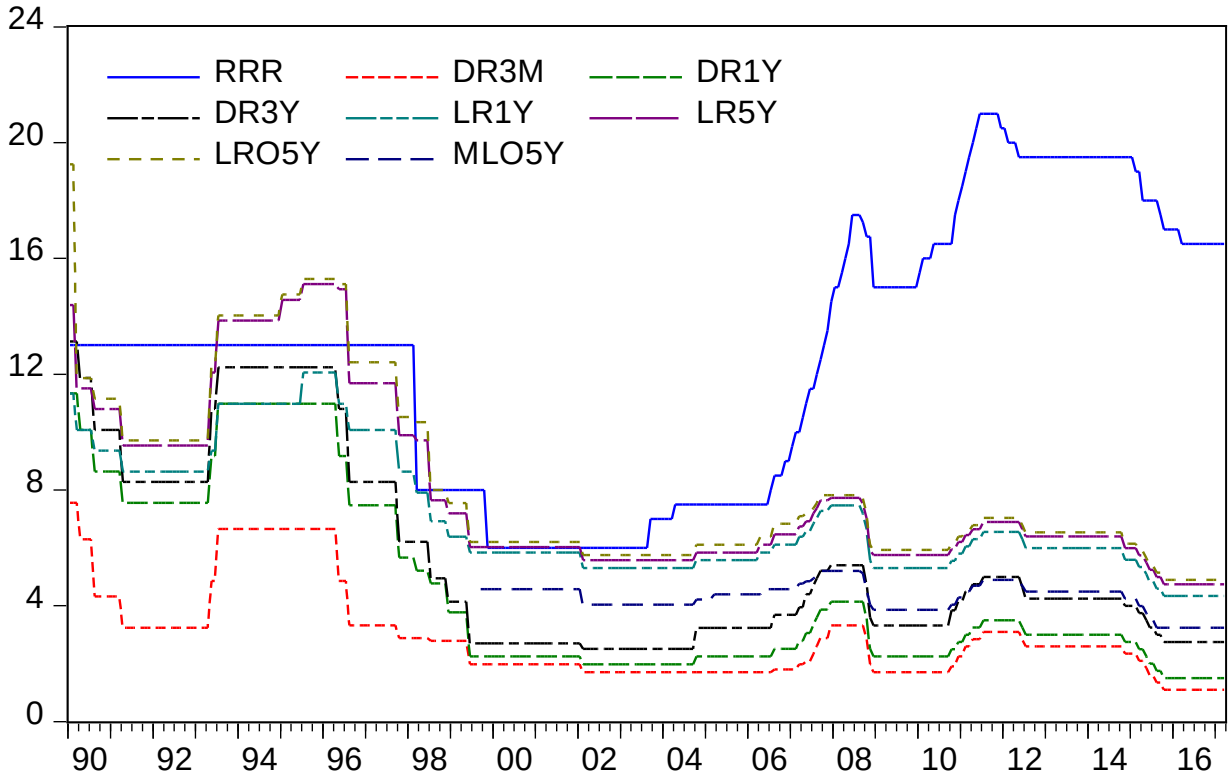
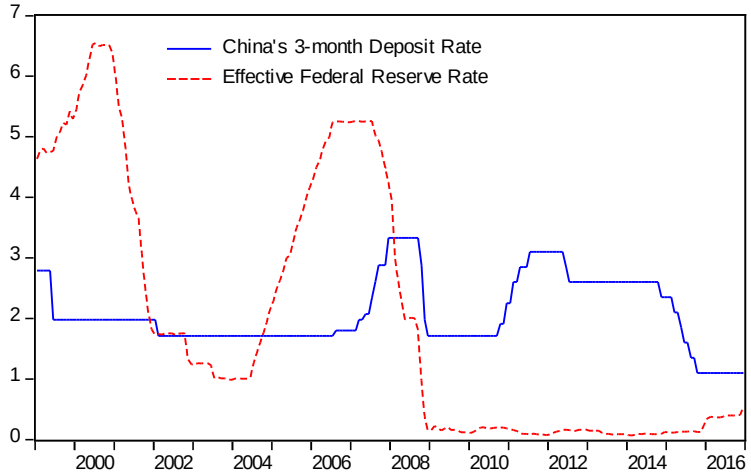
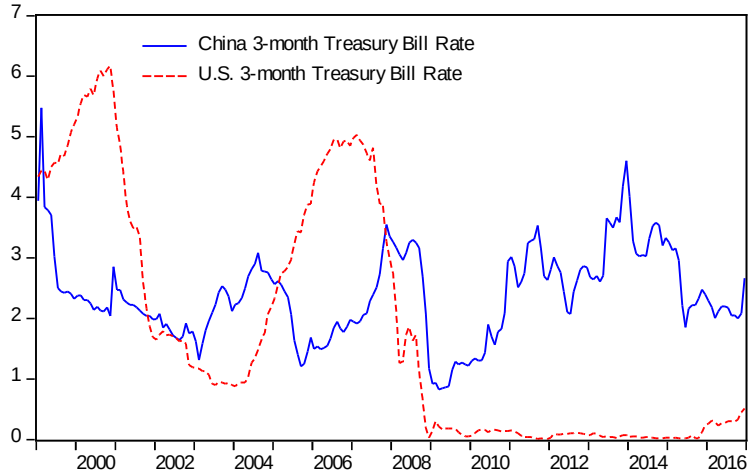
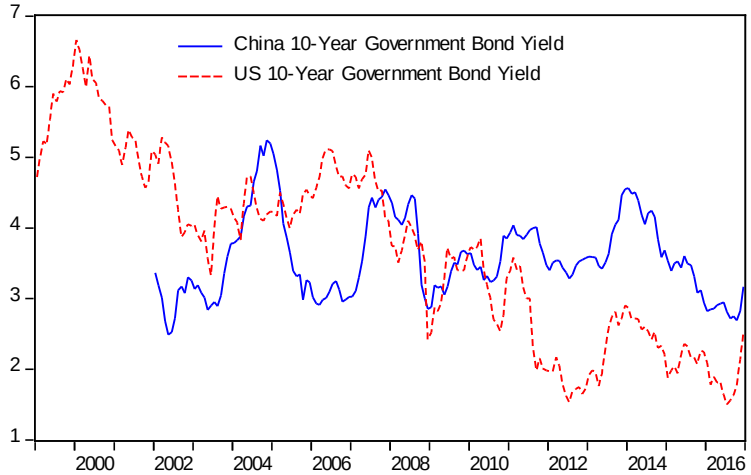


Figure 5. Domestic RMB yields and USD yields







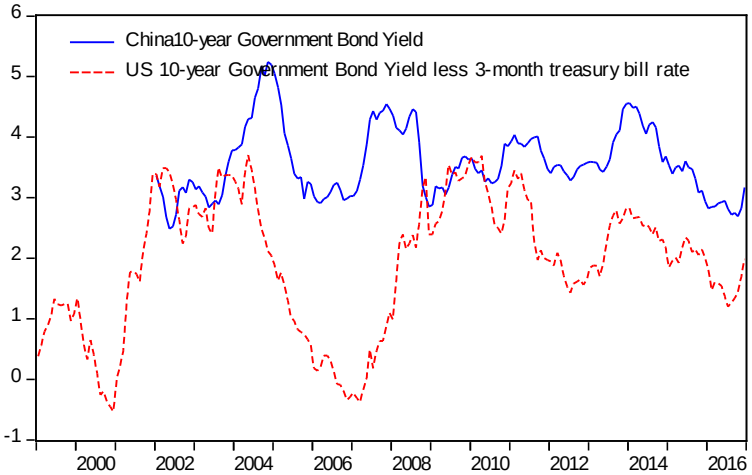


Figure 6. Domestic RMB yields less USD yields

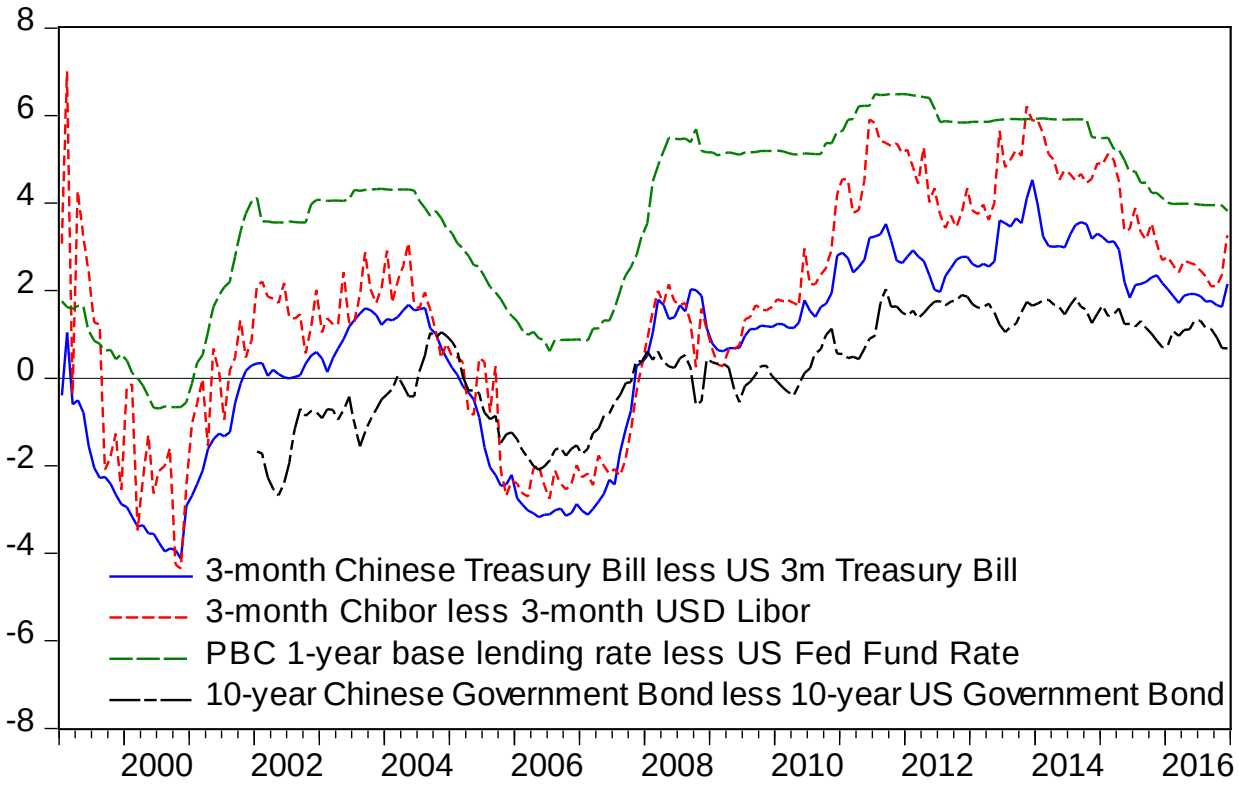
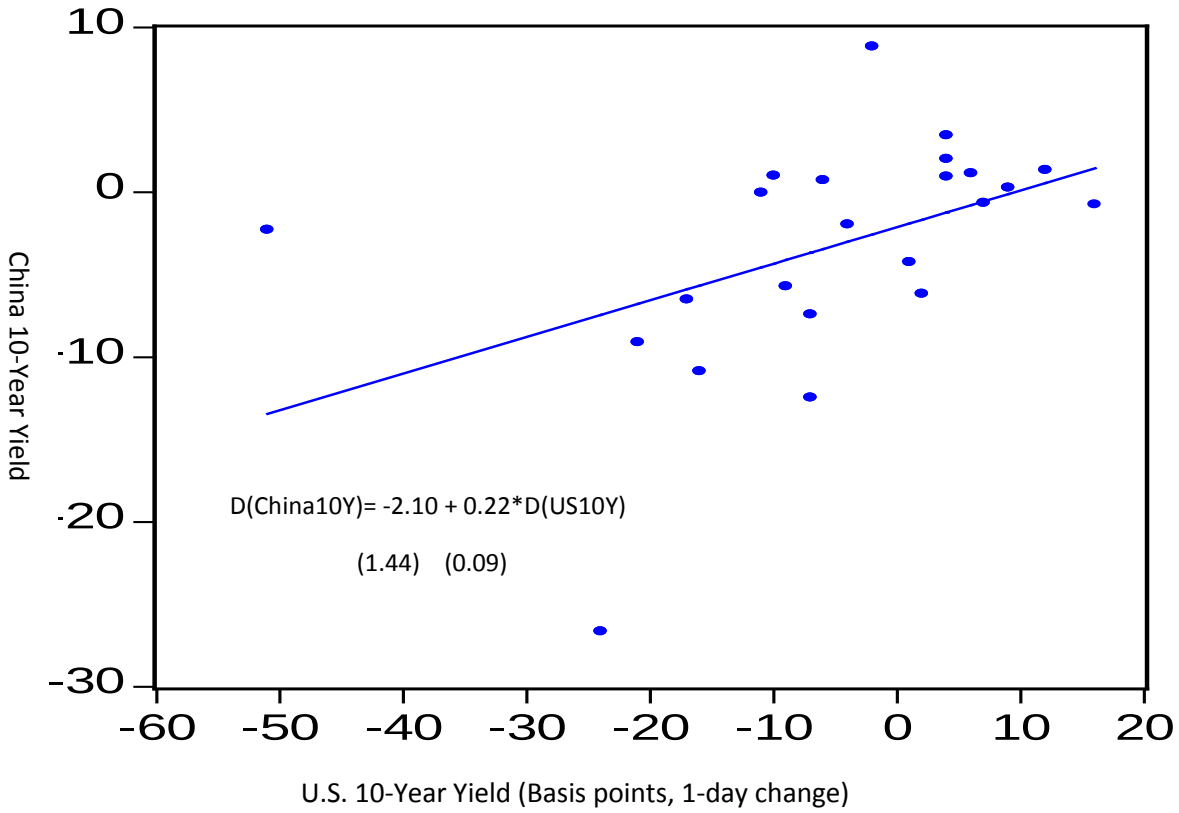


Figure 7 Quantitative Easing and Forward Guidance Announcement (2008-2013) *



*23 announcements between 2008-2013.

Figure 8. Positive and negative components of U.S. interest rates

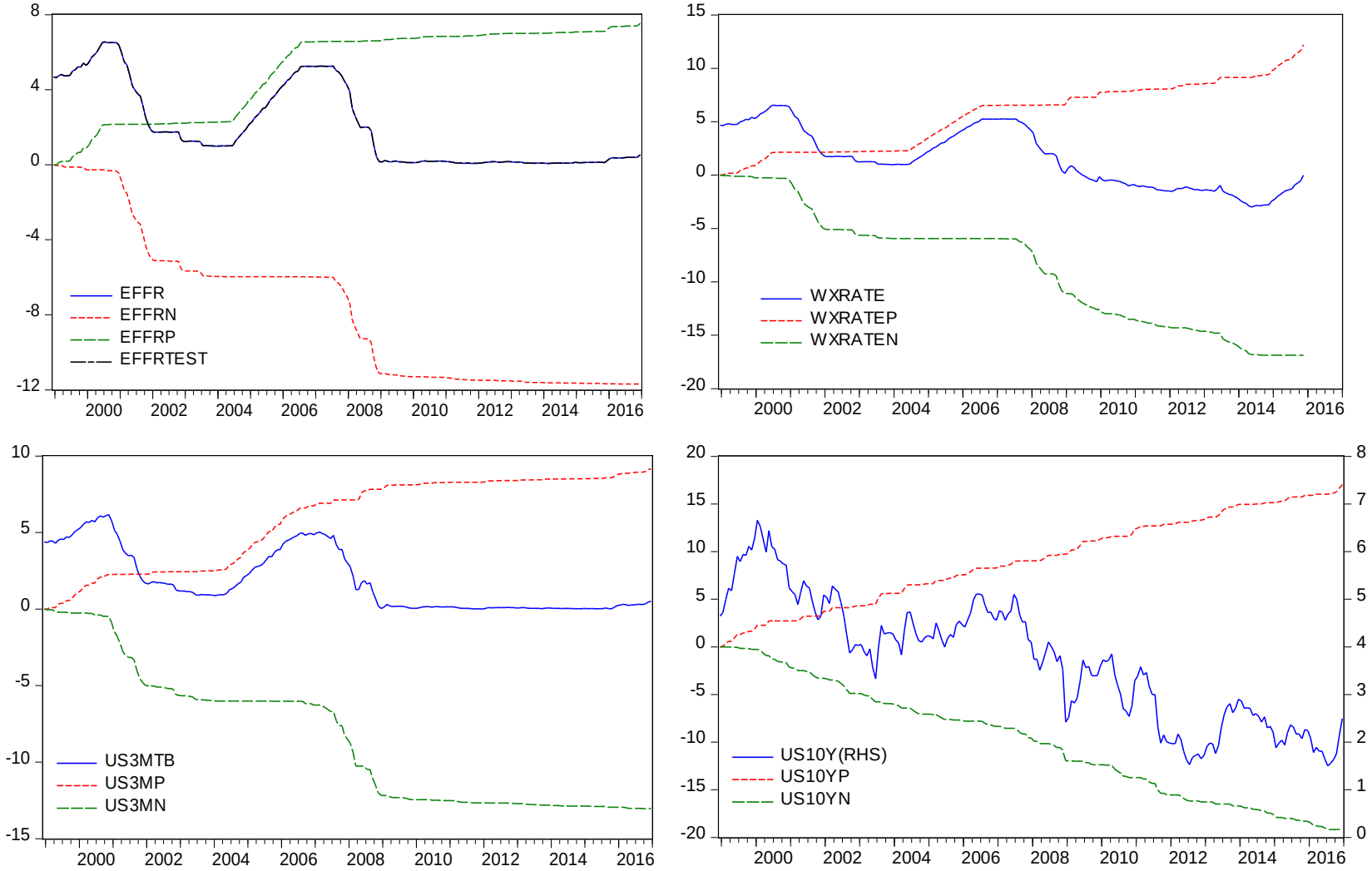
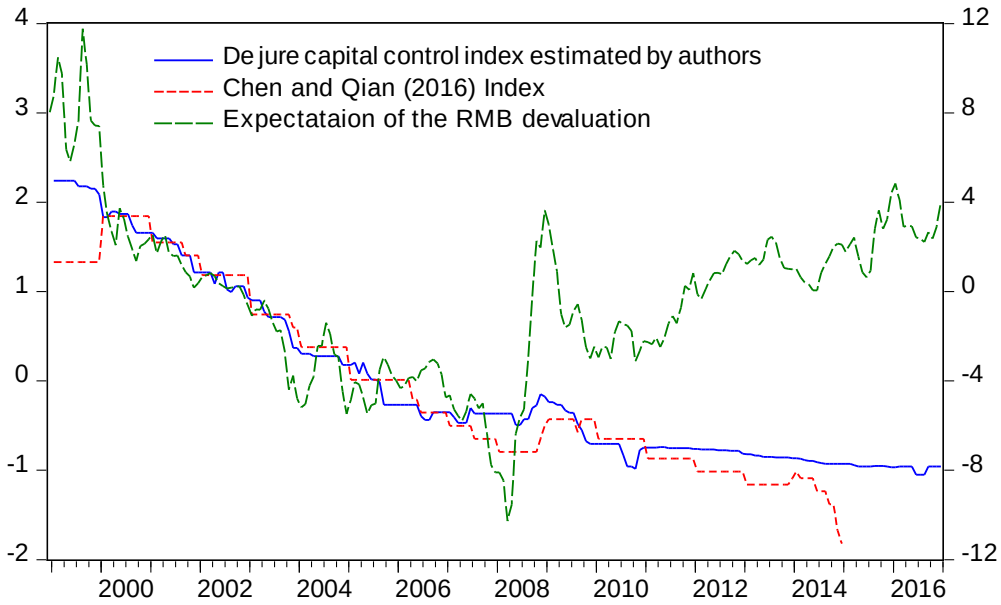


Figure 9. Capital controls and devaluation expectation of RMB



Note: By scoring the 43 sub-items in the 12 categories under capital account, we construct a monthly de jure capital control index based on the method of Jin (2004) and Gou et al. (2012). A higher value in the index indicates more stringent controls on cross-border capital flows.

Table 1.
Interest rates in United States and China: descriptive statistics

	Policy Rate		Short-term Rate		Long-term Rate	
Panel A: Pre-crisis (01/1999-03/2007)						
	EFFR	DR3M	US3MTB	CHIBOR3M	US10YGB	CHINA10YGB*
Mean	3.482	1.861	3.267	2.588	4.828	3.483
Median	3.653	1.710	3.440	2.510	4.720	3.208
Maximum	6.545	2.790	6.170	6.280	6.660	5.241
Minimum	0.984	1.710	0.880	1.490	3.330	2.488
Std. Dev.	1.882	0.248	1.734	0.689	0.733	0.717
Skewness	0.044	2.600	0.015	2.059	0.563	1.156
Kurtosis	1.499	10.205	1.512	11.04	2.596	3.256
Jarque-Bera	9.322	325.679	9.143	336.77	5.911	14.215
Probability	0.009	0.000	0.010	0.000	0.052	0.001
Sum	344.734	184.230	323.390	256.215	478.020	219.456
Sum Sq. Dev.	347.234	6.040	294.793	46.526	52.722	31.865
Observations	99	99	99	99	99	63
Panel B: Post-crisis (01/2009-12/2016)						
	EFFR	DR3M	US3MTB	CHIBOR3M	US10YR	CHINA10YGB*
Mean	0.162	2.141	0.111	3.973	2.491	3.541
Median	0.137	2.350	0.080	4.091	2.345	3.512
Maximum	0.535	3.100	0.510	6.454	3.850	4.562
Minimum	0.066	1.100	0.010	1.380	1.500	2.690
Std. Dev.	0.097	0.656	0.100	1.377	0.645	0.443
Skewness	1.779	-0.223	1.563	-0.235	0.443	0.274
Kurtosis	5.563	1.783	5.542	2.000	2.079	2.766
Jarque-Bera	76.920	6.720	64.946	4.881	6.534	1.419
Probability	0.000	0.035	0.000	0.087	0.038	0.492
Sum	15.593	205.580	10.630	381.416	239.140	339.954
Sum Sq. Dev.	0.891	40.834	0.955	180.044	39.477	18.610
Observations	96	96	96	96	96	96

Note: Data for China ten-year government bond yield is only available from January 2002.

Table 2.
Unit root tests in pre-crisis and post-crisis periods

	Pre	Post
EFFR	-1.12	-6.54***
Δ(EFFR)	-3.96***	-4.62***
DR3M	-3.99***	-1.22
Δ(DR3M)	-9.62***	-7.53***
US3M	-1.69	-6.89***
Δ(US3M)	-2.53	-6.36***
Chbir3M	-3.568***	-2.46*
Δ(Chibor3M)	-14.31***	-11.382***
US10Y	-1.488	-2.652***
Δ(US10Y)	-7.476***	-8.173***
China10Y	-2.077	-3.049**
Δ(China10Y)	-3.353***	-6.457***

Note: The tables contains the ADF test statistics. *, ** and *** indicate rejecting the null hypothesis, i.e., a unit root exists, significantly at the 10%, 5% and 1% levels respectively.

Table 3.
Spillovers of benchmark policy rates from US. to. China

	DR3M	
Panel A: Pre-crisis	(1)	(2)
EFFR	-0.001 (0.022)	0.015 (0.593)
Peg*EFFR	0.022 (0.014)	0.019 (0.021)
Inflation Gap	0.002 (0.014)	0.017 (0.022)
Output Gap	0.024* (0.013)	0.025 (0.018)
ExpDev	0.014* (0.007)	-0.001 (0.011)
VIX		0.016** (0.007)
F_{PSS}	8.671***	6.193***
$\overline{R}^2$	0.890	0.897
Half-life (in months)	5.1	6.2
Panel B: Post-crisis	(3)	(4)
EFFR+	7.367** (3.498)	9.419** (4.766)
EFFR-	-19.604** (7.405)	-27.656** (10.089)
PEG*EFFR+	18.913** (8.152)	22.970** (10.194)
PEG*EFFR-	11.634** (4.961)	14.233** (6.224)
Inflation Gap	0.283** (0.129)	0.501** (0.224)
Output Gap+	-0.864** (0.357)	-1.539** (0.633)
Output Gap-	0.439*** (0.134)	0.565*** (0.187)
ExpDev	-0.102 (0.099)	0.044 (0.133)
VIX		-0.089* (0.049)
F_{PSS}	7.141**	7.141**
$\overline{R}^2$	0.987	0.987
Half-life (in months)	17.9	22.2

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 4.
Spillovers of U.S. monetary policy to China's policy rate after the crisis

	DR3M	
Post-crisis era	(1)	(2)
Twist	0.616 (0.505)	0.540 (0.561)
Peg*Twist	-0.527* (0.288)	-0.573* (0.344)
Inflation Gap	0.323 (0.243)	0.546 (0.473)
Output Gap+	-0.116 (0.188)	-0.356 (0.409)
Output Gap-	0.107*** (0.041)	0.123*** (0.050)
ExpDev	0.228 (0.173)	0.403 (0.348)
VIX		-0.074 (0.079)
F_{PSS}	4.419***	4.327***
$\overline{R}^2$	0.985	0.985
Half-life (in months)	34.1	39.1

Note: The specification estimated is determined by only allowing the significantly asymmetric response according to Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 5.
Spillovers of short-term interest rates from US. to China

	Chibor3M		
Panel A: Pre-crisis	(1)	(2)	(3)
US3M	0.139 (0.115)	0.108 (0.121)	0.016 (0.112)
Peg*US3M	-0.302*** (0.083)	-0.273*** (0.085)	-0.191** (0.095)
Inflation Gap	0.266*** (0.044)	0.298*** (0.050)	0.246*** (0.041)
Output Gap	0.067 (0.079)	0.110 (0.086)	0.070 (0.049)
ExpDev+	-0.105 (0.084)	-0.085 (0.088)	-0.036 (0.067)
ExpDev-	0.055 (0.051)	0.050 (0.053)	0.034 (0.031)
VIX		0.050** (0.020)	0.036** (0.013)
DR3M			1.706** (0.608)
F_{PSS}	3.813**	3.416**	3.336**
$\bar{R}^2$	0.746	0.755	0.776
Half-life (in months)	4.2	4.8	3.9
Panel B: Post-crisis	(4)	(5)	(6)
Twist+	2.138*** (0.259)	2.159*** (0.241)	1.597*** (0.251)
Twist-	-1.305*** (0.405)	-1.482*** (0.452)	-0.820* (0.439)
Peg*Twist+	0.199 (0.639)	-0.673 (0.698)	-1.239** (0.062)
Peg*Twist-	0.217 (0.799)	-0.903 (0.877)	-1.593** (0.768)
Inflation Gap	0.510*** (0.075)	0.557*** (0.112)	0.394*** (0.084)
Output Gap+	-0.239* (0.130)	-0.188 (0.171)	-0.178 (0.111)
Output Gap-	0.470*** (0.108)	0.432*** (0.090)	0.336** (0.116)
ExpDev+	-0.181** (0.088)	-0.227** (0.112)	-0.080 (0.508)
ExpDev-	0.215 (0.141)	0.302 (0.184)	0.098 (0.124)
VIX		0.008 (0.028)	0.013 (0.017)
DR3M			0.794** (0.298)
F_{PSS}	4.374***	4.648*	2.774*
$\bar{R}^2$	0.899	0.900	0.879
Half-life (in months)	1.9	1.8	2.6

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to the Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 6.
Spillovers of long-term interest rates from US. to China

	China10Y					
Panel A: 2002-2016	(1)		(2)		(3)	
US10Y+	1.538***	(0.349)	1.367***	(0.223)	1.464***	(0.242)
US10Y-	-0.420**	(0.217)	-0.441**	(0.162)	-0.870***	(0.269)
Peg*US10Y+	-0.527	(0.359)	-0.858**	(0.294)	-0.626**	(0.304)
Peg*US10Y-	-0.559*	(0.333)	-0.888**	(0.277)	-0.627**	(0.279)
Inflation Gap	0.190**	(0.063)	0.231***	(0.047)	0.268***	(0.061)
Output Gap+	-0.269***	(0.072)	-0.244***	(0.046)	-0.260***	(0.048)
Output Gap-	0.355***	(0.076)	0.345***	(0.050)	0.526***	(0.105)
ExpDev	-0.067	(0.057)	-0.018	(0.039)	-0.054	(0.048)
VIX			-0.034**	(0.012)	-0.024**	(0.011)
DR3M					-0.863**	(0.302)
F_{PSS}	3.126*		3.925***		3.772***	
$\bar{R}^2$	0.948		0.950		0.949	
Half-life (in months)	13.6		10.8		12.1	
Panel B: Post-crisis	(4)		(5)		(6)	
US10Y+	1.013***	(0.101)	0.989***	(0.095)	1.075***	(0.107)
US10Y-	0.014	(0.150)	-0.112	(0.121)	-0.304**	(0.143)
Peg*US10Y+	-0.718***	(0.176)	-0.625***	(0.134)	-0.695***	(0.169)
Peg*US10Y-	-0.639***	(0.161)	-0.544***	(0.125)	-0.597***	(0.155)
Inflation Gap	0.003	(0.031)	0.007	(0.027)	0.035	(0.027)
Output Gap+	-0.068	(0.048)	-0.121**	(0.043)	-0.218**	(0.043)
Output Gap-	0.210***	(0.032)	0.226***	(0.026)	0.287***	(0.044)
ExpDev	-0.089**	(0.039)	-0.109***	(0.033)	-0.107**	(0.007)
VIX			-0.003	(0.006)	-0.018**	(0.007)
DR3M					-0.102	(0.117)
F_{PSS}	3.473**		3.957***		3.643***	
$\bar{R}^2$	0.941		0.955		0.954	
Half-life (in months)	4.0		4.3		4.6	

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to the Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 7.
Capital control and spillovers from U.S. to China after the crisis

	Chibor3M			
Panel A:	(1)		(2)	
Twistp+	1.734***	(0.096)	1.725***	(0.372)
Twistn-	-0.527	(0.145)	-0.394	(0.545)
Peg*twistp+	-1.607**	(0.202)	-1.339*	(0.790)
Peg*twistn-	-2.039**	(0.187)	-1.691*	(1.008)
CC*twistp+	0.213	(0.058)	0.253	(0.208)
CC*twistn-	0.289	(0.058)	0.326*	(0.175)
Inflation Gap	0.456***	(0.034)	0.396***	(0.121)
Output Gap+	-0.224	(0.043)	-0.141	(0.205)
Output Gap-	0.457***	(0.034)	0.428**	(0.156)
ExpDev	0.147	(0.040)	0.107	(0.101)
VIX			0.024	(0.020)
DR3M	0.885**	(0.434)	0.890**	(0.423)
F_{PSS}	2.255		2.147	
$\bar{R}^2$	0.885		0.886	
Half-life (in months)	3.6		3.6	
	China10Y			
Panel B:	(1)		(2)	
US10Y+	1.005***	(0.096)	0.986***	(0.090)
US10Y-	0.007	(0.145)	-0.113	(0.120)
Peg*US10Y+	-0.612***	(0.202)	-0.547***	(0.156)
Peg*US10Y-	-0.543***	(0.187)	-0.473***	(0.146)
CC*US10Y+	-0.084	(0.058)	-0.067	(0.049)
CC*US10Y-	-0.082	(0.058)	-0.069	(0.053)
Inflation Gap	-0.005	(0.034)	-0.001	(0.028)
Output Gap+	-0.082*	(0.043)	-0.133**	(0.045)
Output Gap-	0.208***	(0.034)	0.222***	(0.026)
ExpDev	-0.089**	(0.040)	-0.109**	(0.033)
VIX			-0.003	(0.006)
F_{PSS}	2.937*		3.306**	
$\bar{R}^2$	0.940		0.954	
Half-life (in months)	3.9		4.5	

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to the Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 8.
Spillovers of policy rates from US. to NZ

	OCR	
Panel A: Pre-crisis	(1)	(2)
EFFR	0.287***	0.293***
	(0.038)	(0.038)
Inflation Gap	0.389***	0.399***
	(0.138)	(0.064)
Output Gap	0.239	0.220***
	(0.147)	(0.141)
ExpDev	-0.031	-0.020
	(0.022)	(0.027)
VIX		0.014
		(0.015)
F_{PSS}	4.914***	4.176***
$\bar{R}^2$	0.980	0.980
0Half-life (in months)	10.5	10.1
Panel B: Post-crisis	(3)	(4)
TWIST	0.478***	0.594***
	(0.105)	(0.116)
Inflation Gap	-0.295***	-0.274***
	(0.079)	(0.063)
Output Gap	-0.548***	-0.548***
	(0.105)	(0.104)
ExpDev	0.010	0.001
	(0.034)	(0.030)
VIX		-0.028**
		(0.012)
F_{PSS}	7.394***	7.094***
$\bar{R}^2$	0.940	0.939
Half-life (in months)	9.1	8.8

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 9.
Spillovers of floating retail rates from US. to NZ

	MortgageF			
Panel A: Pre-crisis	(1)	(2)	(3)	(4)
EFFR	0.129***	0.125***	0.004	0.006
	(0.048)	(0.043)	(0.009)	(0.011)
Inflation Gap	0.851***	0.833***	0.031	0.059*
	(0.126)	(0.095)	(0.032)	(0.035)
Output Gap	0.577***	0.589***	0.036*	0.050**
	(0.193)	(0.160)	(0.020)	(0.023)
ExpDev	0.024	0.001	0.013***	0.008
	(0.021)	(0.030)	(0.003)	(0.006)
VIX		-0.040*		-0.005
		(0.023)		(0.004)
OCR			0.968***	0.945***
			(0.042)	(0.052)
F_{PSS}	5.285***	5.155***	8.734***	3.577**
$\bar{R}^2$	0.980	0.981	0.991	0.981
Half-life (in months)	10.1	10.3	2.4	2.8
Panel B: Post-crisis	(5)	(6)	(7)	(8)
TWIST	0.365***	0.574***	-0.137	-0.105*
	(0.083)	(0.098)	(0.083)	(0.056)
Inflation Gap	-0.175***	-0.199***	0.068	0.044
	(0.052)	(0.039)	(0.046)	(0.032)
Output Gap	-0.412***	-0.494***	-0.038	-0.038
	(0.071)	(0.077)	(0.075)	(0.057)
ExpDev	0.041	0.018	0.032*	0.029**
	(0.023)	(0.022)	(0.017)	(0.012)
VIX		-0.042***		0.007*
		(0.013)		(0.004)
OCR			0.775***	0.790***
			(0.107)	(0.088)
F_{PSS}	5.203***	18.681***	3.349*	3.506**
$\bar{R}^2$	0.939	0.952	0.976	0.978
Half-life (in months)	8.7	7.1	9.8	8.3

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 10.
Spillovers of mid-term retail rates from US. to NZ

	Mortgage2Y			
Panel A: Pre-crisis	(1)	(2)	(3)	(4)
US10Y	0.658***	0.668***	0.533***	0.533***
	(0.189)	(0.121)	(0.033)	(0.036)
Inflation Gap	0.531	0.203	0.085	0.083
	(0.365)	(0.213)	(0.085)	(0.089)
Output Gap	0.677	0.398*	0.204***	0.213***
	(0.441)	(0.208)	(0.049)	(0.055)
ExpDev	-0.033	-0.002	-0.003	-0.012
	(0.063)	(0.048)	(0.008)	(0.011)
VIX		-0.028		-0.011
		(0.032)		(0.010)
OCR			0.347***	0.334***
			(0.102)	(0.113)
F_{PSS}	1.323	1.446	7.113***	6.171***
$\bar{R}^2$	0.922	0.925	0.928	0.929
Half-life (in months)			3.2	3.9
Panel B: Post-crisis	(5)	(6)	(7)	(8)
TWIST	0.759***	0.738***	0.531***	0.548***
	(0.169)	(0.257)	(0.099)	(0.111)
Inflation Gap +	0.830**	0.657**	0.293*	0.299*
	(0.360)	(0.310)	(0.163)	(0.173)
-	-0.255**	-0.371**	-0.035	-0.041
	(0.109)	(0.163)	(0.053)	(0.056)
Output Gap +	-0.593***	-0.620***	-0.284**	-0.292**
	(0.188)	(0.215)	(0.117)	(0.126)
-	0.795**	0.895*	0.265	0.259
	(0.372)	(0.259)	(0.172)	(0.172)
ExpDev	0.091**	0.029	0.064**	0.064**
	(0.035)	(0.047)	(0.027)	(0.028)
VIX		-0.058**		0.003
		(0.024)		(0.010)
OCR			-0.031	-0.049
			(0.141)	(0.146)
F_{PSS}	4.765***	6.236***	8.144***	7.484***
$\bar{R}^2$	0.979	0.983	0.983	0.982
Half-life (in months)	18.9	15.6	9.3	9.4

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.

Table 11.
Spillovers of long-term rates from US. to NZ

	NZ10Y			
Panel A: Pre-crisis	(1)	(2)	(3)	(4)
US10Y	0.441***	0.440***	0.538***	0.539***
	(0.118)	(0.115)	(0.102)	(0.102)
Inflation Gap	-0.072	-0.060	0.161	0.162
	(0.168)	(0.175)	(0.146)	(0.146)
Output Gap	0.021	0.017	0.124	0.121
	(0.096)	(0.089)	(0.084)	(0.079)
ExpDev	-0.043*	-0.032*	-0.021	-0.017
	(0.018)	(0.020)	(0.016)	(0.021)
VIX		0.012***		-0.004
		(0.026)		(0.021)
OCR			-0.272**	-0.268**
			(0.126)	(0.125)
F_{PSS}	2.065	1.446	2.244	2.003
$\bar{R}^2$	0.972	0.925	0.928	0.968
Half-life (in months)				
Panel B: Post-crisis	(5)	(6)	(7)	(8)
US10Y	1.503***	1.443***	1.513***	1.484***
	(0.070)	(0.133)	(0.109)	(0.194)
Inflation Gap	-0.032	-0.032	-0.038	-0.176
	(0.033)	(0.033)	(0.058)	(0.127)
Output Gap	-0.246***	-0.229**	-0.260**	-0.274
	(0.069)	(0.109)	(0.123)	(0.217)
ExpDev	-0.113***	-0.152***	-0.112***	-0.152***
	(0.016)	(0.031)	(0.018)	(0.033)
VIX		0.060***		0.062***
		(0.018)		(0.023)
OCR			-0.023	-0.069
			(0.158)	(0.291)
F_{PSS}	5.719***	5.283***	4.851***	5.283***
$\bar{R}^2$	0.988	0.990	0.988	0.990
Half-life (in months)	4.9	8.1	5.1	8.7

Note: The specification estimated in each sample period is determined by only allowing the significantly asymmetric response according to Wald Test. The standard errors are in parentheses; *, ** and *** indicate significance at the 10%, 5% and 1% levels respectively. An intercept for every estimation is included but not reported for brevity.