U.S. monetary policy uncertainty and RMB deviations from covered interest parity

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Abstract:

This paper examines how U.S. monetary policy uncertainty (MPU) affects RMB deviations from covered interest parity (CIP) and how this effect is influenced by China's capital controls, the RMB exchange rate regime, and international reserves that constrain the transmitting channel of U.S. MPU shocks. Our findings show that U.S. MPU has a spillover effect and creates deviations from RMB CIP. Capital controls insulate uncertainty shocks and alleviate the U.S. MPU spillover effect. There are some evidences that international reserves alleviate and the liberalized RMB exchange rate regime magnifies the spillover effect. However, their effects become insignificant in the presence of capital controls. Moreover, the U.S. MPU effect on RMB CIP deviation became prominent after the 2008 global financial crisis.

Keywords: U.S. MPU, deviation from CIP, RMB cross-currency basis, capital controls, exchange rate regime, international reserves
JEL Classifications: E43, F31, G15

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1. Introduction

Since the 2008 global financial crisis, there have been large and persistent deviations from covered interest parity (CIP) among the world's major currencies such as the U.S. dollar, Euro, and Yen. This phenomenon is at odds with CIP theory, which states that when cross-border transactions are absent of capital controls and frictionless, returns are identical for an investor holding local currency assets versus exchanging local currency at the spot market and holding foreign currency assets while hedging transactions with forward contracts.

The issue has spurred a surge in studies attempting to identify its plausible causes [see, for example, Avdjiev et al. (2019), Du et al. (2018), and Ivashina et al. (2015)[1]]. These papers find that in addition to credit risk and transaction costs, a key factor that drives deviations from CIP among the world's major currencies is constraint on arbitrage funds, and on U.S. dollars in particular, primarily due to government regulations on bank and/or credit risks.

This reason has been identified by studying data of deviations from CIP among the world's major currencies that are absent of capital controls and under flexible exchange regimes. However, it is unclear whether constraints on arbitrage funds cause deviations from CIP between, for instance, the U.S. dollar and emerging market currencies that are usually subject to capital controls and/or in peg exchange rate regimes? If they do, how would capital controls and exchange rate regimes affect the effect of constraints of arbitrage funds on deviations from CIP?

This paper uses Chinese renminbi (RMB) data to empirically study how constraints on U.S. dollar funds affect deviations of RMB CIP. Because there is no direct measurement for U.S. dollar funds associated with RMB market, we use U.S. monetary policy uncertainty (MPU) to proxy the supply of arbitraging U.S. dollars where a high level of U.S. MPU represents low U.S. dollar arbitrage funds in offshore RMB markets. U.S. monetary shocks are found to have a substantial influence on cross-border capitals that flow from the U.S. to emerging market economies (EMEs) and vice versa. The framework is pioneered in Calvo et al. (1996)[2] and is advanced by the "global financial cycle" argument proposed by Miranda-Agrippino and Rey (2015) and Rey (2015). U.S. monetary policy shocks induce comovements in the international

[1] See also, for example, Borio et al. (2018) and Bottazzi et al. (2012).

[2] Calvo et al. (1996) find the tightening and loosening of U.S. monetary policy to drive the boom and bust cycles of capital flows in developing countries of Latin American and Asia. Similar findings are given in Fratzscher (2012) and Forbes and Warnock (2012).

financial variables that characterize the "Global Financial Cycle." A tightening shock of U.S. monetary policy leads to a significant deleveraging of global financial intermediaries, a decline in the provision of domestic credit globally, strong retrenchments of international credit flows, and a tightening of foreign financial conditions.

Following the global financial cycle paradigm, we argue that a loose U.S. monetary policy that booms U.S. dollars to China and later retrenches of U.S. dollars from China results from a tightened shock on U.S. monetary policy creating spillover effects and distorting the demand and supply of RMB assets aligned with China's macroeconomic conditions. This distortion generates a wedge between onshore and offshore RMB asset yields and thus a deviation from RMB covered interest rate parity.

Following the literature, we use *cross-currency basis* to measure deviations in RMB CIP (Borio et al. 2018; Du et al., 2018), which are measured as the difference between the RMB interest rate from onshore money markets and the offshore synthetic RMB interest rate obtained by converting U.S. dollars into RMB. When the basis is zero, CIP holds. A positive (negative) cross-currency basis means that the onshore RMB interest rate is higher (lower) than the offshore synthetic RMB interest rate. We find that an uptick in U.S. MPU is associated with a lower RMB cross-currency basis. More specifically, the RMB cross-currency basis decreases by approximately 0.06 percent in response to a one percent increase in U.S. monetary policy uncertainty.

To understand how U.S. MPU transmits its spillover effect onto the RMB basis (for simplicity, we abbreviate the RMB cross-currency basis as the RMB basis), we examine how macroeconomic conditions and policies that may limit the spillover channel influence of the effect of U.S. MPU on the RMB basis. Following Rey's global financial cycle theory, we suggest that U.S. MPU transmits its impact and creates spillover effects via global bank deleverage and capital retrenchment from China and other EMEs. In essence, U.S. MPU affects the RMB basis through cross-border capital flows. We consider three macroeconomic conditions and policies, namely, capital controls, the RMB exchange rate regime, and international reserves that could insulate or cushion U.S. MPU spillovers when transmitted through cross-border capital flows.

Capital controls impose a direct restriction on cross-border capital flows; thus, they insulate external shocks (Zeev, 2017) transmitted through cross-border capital flows, e.g., U.S. MPU shocks. Indeed, our results indicate that capital controls alleviate the impact of U.S. MPU on the RMB basis. In particular, the marginal effect of U.S. MPU is reduced by 0.22 as China tightens its capital controls by one standard deviation as measured by the index from Fernández et al. (2016).

Capital control is commonly known as a canonical factor that drives deviations from CIP, as it acts as a Tobin tax (Tobin, 1974) that increases cross-border transaction costs. Our study confirms this canonical effect. Moreover, by pointing out that capital controls reduce the spillover effect of U.S. MPU on the RMB basis, we reveal an externality of capital controls on CIP deviation rarely discussed in the literature – while capital controls drive deviations from CIP, they limit the impact of external shocks on CIP deviations. Further, in analyzing the interaction between capital controls and U.S. MPU, we find that both the direction and degree of marginal effects of China's capital controls on the RMB basis depend on the level of U.S. MPU - the higher (lower) the magnitude of a U.S. MPU shock, the more positive (negative) the effect that capital controls have on the RMB basis. The direction of the capital control effect switches from negative to positive around the mean level of U.S. MPU (approximately 4.76).

The RMB exchange regime shapes the impact of U.S. MPU on the RMB basis. From various measurements for RMB exchange rate arrangement, we show that the gradual liberalization of the fixed RMB exchange rate regime magnifies the negative effect of U.S. MPU on the RMB basis, which is consistent with Rajan's (2015) argument that the exchange rate flexibility in spillover recipient countries sometimes exacerbates booms rather than equilibrating them. However, our finding is seemingly at odds with Obstfeld et al.'s (2019) finding that a fixed exchange rate tends to amplify the transmission of global financial shocks relative to more flexible regimes. It may be that although the RMB exchange regime becomes more liberalized from hard peg, it acts as a managed float and in some ways it is still a de facto peg to the U.S. dollar (Prasad and Wei, 2007).

Regarding how international reserves influence the spillover of U.S. MPU shocks, our results indicate that China's active reserve management helps reduce U.S. MPU spillover effects on the RMB basis. In fact, the negative marginal effect of U.S. MPU on the RMB basis can be reversed with extraordinary increases in international reserve accumulation. These findings echo those found in Dominguez et al. (2012) and Aizenman and Jinjarak (2020). These authors find that countries implementing countercyclical management of international reserves in good times and selling them in bad times provides buffer stock financial serveries with positive impacts on a country's economic and financial performance.

In addition to working through the channel of cross-border capital flows, we explore whether U.S. MPU may affect the liquidity of the RMB foreign exchange (FX) hedge market, further affecting the RMB basis. Iida et al. (2018) find that financial shocks from the U.S. contract bank credit and cause global U.S. dollar fund shortfalls, which reduce the supply for FX hedge contracts (e.g., FX forward and swap) and drive deviations from CIP. Following their argument, we find evidence that a shallow RMB non-deliverable forward (NDF) market reduces the RMB basis. When interacted with U.S. MPU, a shallow RMB NDF market is also found to amplify the spillover effect on U.S. MPU. The 2008 global financial crisis changed the landscape of global U.S. dollar fund availability largely due to renewed government regulations designed to curb banks' risk-taking behavior to maintain global financial instability. Consequently, bank funds for supplying FX hedge contracts have been lower since the 2008 financial crisis (Avdjiev et al, 2019). Consistent with these authors' findings, we find the spillover effect of U.S. MPU on the RMB basis to be more prominent since the 2008 financial crisis.

Our study contributes to the literature in at least two respects. First, we identify a specific external factor, U.S. MPU, that significantly affects the RMB basis. Most past works focus on domestic characteristics such as country risk (Keynes, 1923; Frankel 1991) and controls on capital mobility (Dooley and Isard, 1980; Ito, 1983) while paying less attention to external factors, perhaps due to difficulties with detangling and measuring external shocks, as these shocks are a mixture of global and reginal shocks and are usually correlated with country specific shocks. We use U.S. MPU to represent a common shock that comoves global, regional, and Chinese financial variables. U.S. MPU essentially represents an aggregate external shock that shocks the Chinese economy either directly or by triggering global, regional, and country specific shocks to affect it indirectly.

Second, this paper examines how the U.S. MPU spillover effect drives a wedge between onshore and offshore yields of RMB assets. It suggests that U.S. MPU affects the demand and supply of global U.S. dollar funds and induces distorted cross-border capital flows, which drives deviations from RMB CIP. This channel has been confirmed among currencies of major industrial economies. For instance, Ivashina et al. (2015) find that a dollar shortfall in the U.S. dollar and Euro Swap market leads to violation of covered interest rate parity. Du et al. (2018) argue that CIP deviations can be attributed to constraints on financial intermediaries and to international imbalances in investment demand and funding supply across world major currencies[3]. However, whether this channel works for emerging economies that effectively limit capital mobility and adopt less flexible exchange regimes remains undetermined. We focus on Chinese RMB, which is subject to evolving capital controls and managed exchange rate regimes. Our results suggest that the channel is working, and we confirm that capital controls significantly reduce, whereas the RMB exchange regime magnifies in the absence of capital controls, the magnitude with which U.S. MPU affects the RMB basis. Additionally, we study how China's stockpile of international reserves may help soothe U.S. MPU shocks on the RMB basis.

The remainder of the paper is organized as follows. Section 2 discusses the estimation methodology and data. Section 3 presents empirical evidence for the effect of U.S. MPU on the RMB basis and for how capital controls, RMB exchange regimes, and international reserves change the impact of U.S. MPU on the RMB basis. We conclude in section 4.

2. Data and the empirical methodology

To empirically study how U.S. MPU affects the RMB basis, we obtain monthly Chinese data for January 1999 to June 2020[4]. The RMB basis is calculated as the difference between the 1-month onshore RMB interest rate and offshore synthetic interest rate with an FX hedge in non-deliverable forward (NDF). More specifically, basis = $(r-r^*)/(1+r^*) - (F-S)/S$ where r is the Chinese interbank offer rate (CHIBOR), r^* is the US$ LIBOR, F is the RMB NDF 1-month rate, and S is the spot exchange rate (yuan/$). All data are in period average and are retrieved from Bloomberg.

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[3] Similar findings are given in other works. For example, the shortfall of U.S. dollar funds increases marginal costs of global banks that fund the FX swap, which in turn affects deviations of CIP (Iida et al., 2018). Avdjiev et al. (2019) find that the dollar plays a key role in risk-taking capacity in global capital markets and is associated with large deviations from CIP and with contractions of cross-border bank lending in U.S. dollars.

[4] Due to the availability of non-deliverable forward data, our data series starts from January 1999.

For U.S. MPU, we use the monetary policy uncertainty index of Baker et al. (2016) (BBD), which tracks the frequency of articles published on monetary policy uncertainty in 10 major U.S. newspapers[5]. The BBD index is a news-based index that captures the degree of uncertainty that the public perceives about the Federal Reserve's policy stance and its possible consequences. However, it may not necessarily reflect perceptions of the financial market on the Fed's policy uncertainty. For robustness purposes, we use two market-based U.S. MPU measures, namely, the VIX index and Fed's shadow rate (Wu and Xia, 2016). Our use of the VIX is motivated by the finding of Miranda-Agrippino and Rey (2015) that U.S. monetary policy shocks induce comovements in the VIX (a global financial risk gauge), global bank deleverages, risk assets prices, and other international financial variables. Indeed, the U.S. MPU index is highly correlated with the VIX (see Figure 1). The Fed's shadow rate, on the other hand, is a direct measure of the Fed's monetary policy stance. A large change in the Fed's interest rate may suggest tighter monetary policy and a high level of Fed policy uncertainty.

Drawing on the literature, we estimate the following specification to examine how U.S. MPU spillovers lead to deviations of RMB CIP:

$$Y_t = \alpha_0 + \alpha_i Y_{t-i} + \beta_1 MPU_t + \gamma Z_t + \varepsilon_t \qquad (1)$$

where Y_t is the RMB basis in month *t*. MPU_t is the U.S. MPU index (BBD in natural log). Z_t is a set of four relevant variables that control for China's domestic macroeconomic conditions. The first of these four control variables is *M2*, the growth of China's broad money measured by the first difference of broad money to GDP ratio[6], which may turn into capital flight offshore (Obstfeld et al., 2010) and drive deviations from CIP. *Inflation* measures the macroeconomic risk of the Chinese economy. High inflation may indicate high levels of macroeconomic risk that

[5] BBD constructed two MPU indices using the same criteria but based on a different set of newspapers. One index draws on hundreds of U.S. newspapers covered by Access World News, and the other draws on a balanced panel of 10 major national and regional U.S. newspapers. We use the index based on 10 major newspapers for two reasons: first, major newspapers are likely to devote more coverage to esoteric monetary policy matters (quantitative easing, forward guidance, etc.) than the broader set of small newspapers. Second, the index is more similar to another newspaper-based MPU index compiled by Husted et al (2019), but it differs from the BBD index with respect to scaling factors, newspaper coverage and term sets.

[6] M2, trade open, and NEER are tested as I(1); therefore, we perform a first difference before entering them in a regression.

induce an outflow of capital to seek safety. *Trade open*, measured by total imports and exports to GDP ratio (in first difference), captures a channel through which capital moves across borders through international trade. More open trade allows for easier cross-border capital movements. Finally, the NEER, the nominal effective exchange rate (in natural log difference), reflects overall RMB value against a basket of currencies of China's trade partners. A lower NEER may reflect higher competitiveness of the RMB against its trade partners and thus a greater probability of a trade surplus. If U.S. MPU imposes a spillover on the RMB currency basis, β_1, the coefficient of *MPU* in equation (1) is statistically significant.

In addition to investigating the spillover effect of U.S. MPU on the RMB basis, we postulate that such a spillover effect may transmit through cross-border capital flows – a U.S. MPU shock reduces global U.S. dollar fund supply, which causes the retrenchment of capital from China and drives a negative RMB basis. To test this channel, we augment equation (1) with three factors that likely constrain the effectiveness of the transmitting channel and change the spillover effect of U.S. MPU on the RMB basis: China's capital controls (*KC*), RMB exchange regimes (*RMB rgm*), and international reserves (*reserves*). The augmented specification is:

$$Y_t = \alpha_0 + \alpha_i Y_{t-i} + \beta_1 MPU_t + \beta_2 X_t + \beta_3 MPU_t \times X_t + \gamma Z_t + \varepsilon_t \qquad (2)$$

where X_t lists *KC*, *RMB rgm*, and *reserves*. We estimate them individually and collectively. To measure China's capital controls, we apply Fernández et al.'s (2016) and Chen and Qian's (2016) indices, both of which are *de jour* measurements based on the IMF's Annual Report on Exchange Arrangements and Exchange Restrictions (AREAER). While Chen and Qian (2016) develop a month frequency index, Fernández et al. (2016) provide annual data. For regression purposes, we extrapolate Fernández et al.'s (2016) results into monthly data by allowing the index for each month of a year be equal to its corresponding annual index (i.e., *KC* indices for Jan. to Dec. of 1999 are equal to the *KC* index for 1999). In addition, Chen and Qian's (2016) *KC* indices provide a finer measurement and therefore have more variations than Fernández et al.'s (2016) in that their indices can capture gradual and small steps of China's capital account liberalization process. However, Chen and Qian's (2016) index ends in Dec. 2016. For this reason, we use Fernández et al.'s (2016) index as a benchmark to run our estimation, while uses Chen and Qian's (2016) index as an alternative for robustness checks.

For RMB exchange rate regimes, we first use the fine and coarse measures developed by Ilzetzki et al. (2019). Both measures indicate that while RMB exchange regimes have been more flexible, but they are still restricted. The fine measure indicates that RMB exchange regimes change from 4 (de facto peg) to 7 (de facto crawling peg) from 1999 to 2016 and that the coarse measure changes from 1 (de facto peg) to 2 (de facto crawling peg) in 2006. For ease of regression result interpretation, we rescale both fine and coarse measures and let *Fine* = 0 if it is 4 (de facto peg) and *Fine* = 3 for the case of 7 (de facto crawling peg) in Ilzetzki et al. (2019) while we let *Coarse* = 0 for before 2006 and = 1 for after 2006. Additionally, we create two alternative measures to capture the gradual RMB exchange rate liberalization process that China has been implementing since 1999. One is labeled as *Reform* and measures the RMB exchange rate reform of June 2005. The second is a finer measure and is labeled as *Rgm libl*. It is a ranking measure (i.e., of 1 to 5) with a high numerical score when RMB exchange regimes become more flexible. Appendix A provides detailed explanations for these measurements. Regarding international reserves, we use China's international reserves excluding gold (in natural log difference). Reserves insure against external shocks and thus tend to mitigate the spillover effect of U.S. MPU on the RMB basis. If capital controls, exchange regimes, and reserves effectively constrain the transmitting channel of U.S. MPU shock, we would estimate β_3 to be statistically significant.

We estimate equations (1) and (2) based on monthly time series data using the autoregressive distributed lags model (ARDL), which allows one to include lagged dependent variables as regressors. We use the ARDL model for two reasons. First, Cheung and Qian (2011) find that the RMB basis shows time persistence and that much of its variation can be explained by its history. The ARDL model addresses both possibilities. Second, the ARDL model that includes a lagged dependent variable addresses serial correlations in error terms that cause estimation bias in time series regressions. The lag structure of the lagged dependent variable, Y_{t-i}, in equation (2) is determined by the Bayesian information criterion and by the properties of the estimated residuals.

3. Empirical results

In this section, we present our estimation results. To do so, we adopt a step-by-step approach: we first show how U.S. MPU by itself affects the RMB basis and then add Chinese macroeconomic factors to the regression as laid out in base model equation (1). Next, we estimate equation (2) by adding capital controls, the RMB exchange rate regime, and international reserves individually and then collectively in a regression to examine how these constraints of the U.S. MPU transmission channel influence its spillover effect on the RMB basis individually and collectively. Finally, we explore another plausible mechanism through which U.S. MPU spillover affects the RMB basis.

3.1. U.S. MPU and the RMB basis in the base model

Table 1 reports the base model results. Column 1 shows that MPU is negatively associated with the RMB basis (it is significant at the 5% level) without controlling other relevant factors. Quantitatively, a 1 standard deviation (approximately 0.46) [7] shock to (ln) U.S. MPU lowers the RMB basis by approximately 0.03 percent (0.36 percent of the annual percentage rate), which suggests that U.S. MPU imposes a statistically and economically significant spillover effect on the RMB basis. The lagged dependent variable is significantly positive, indicating the time persistence of the RMB basis (Cheung and Qian, 2011). This simple model explains approximately 74% of RMB basis variation.

Including relevant macroeconomic control variables yields an almost identical estimation for MPU (see column 4). Among these macro control variables, *M2* and *NEER* are significant. The growth of broad money in China stimulates the RMB basis while a high *NEER* reduces the RMB basis. An increase in *NEER* indicates that RMB appreciates in value against a basket of foreign currencies. Given the ultraconservative Chinese exchange rate policy and its enormous intervention capacity, a recent RMB appreciation softens appreciation pressure and reduces investors' expectations of further appreciation, hence reducing the RMB basis. *Inflation* and *Trade open* are insignificant. These control variables provide approximately 1 percent additional explanatory power to the base model.

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[7] Summary statistics are reported in Appendix B.

Considering alternative measures for U.S. MPU, we replace *MPU*, a news-based monetary policy uncertainty measure, with the VIX index (*VIX*, an index that captures the market's perceptions about monetary policy uncertainty) and the Fed's fund rate (*Fed rate*, a direct measure of the Fed's policy stance proxied by the Fed's shadow rate provided in Wu and Xia, 2016). The results, reported in columns 2 and 3, echo the BBD *MPU* results, showing that an increase in the market's risk aversion to U.S. monetary policy uncertainty or a large increase in the Fed's fund rate creates a negative spillover effect on the RMB basis. These results do not materially change when relevant control variables are included (see columns 5 and 6), though the estimation for *Fed rate* is slightly below the 10% level of significance. Overall, we can confirm that U.S. monetary policy uncertainty has a spillover effect on the RMB basis.

3.2. Constraints on the transmitting channel

3.2.1. Capital controls

Next, we examine how constraints on the U.S. MPU shock transmitting channel influence the spillover effect of U.S. MPU. We start from China's capital controls (*KC*) and report regression results in Table 2. As shown in column 1, the coefficient (β_3) on the interaction term, *KC*×*MPU*, is positive and significant at the 1% level, suggesting that capital controls mitigate the spillover effect of U.S. MPU on the RMB basis. A one level tighten-up of capital controls reduces the impact of a 1 standard deviation shock of U.S. MPU on the RMB basis by approximately 1.45 percent. Thus, as capital controls become more restrictive, the overall spillover effect of U.S. MPU on the RMB basis abates and the overall spillover effect may necessarily depend on the restriction level of China's capital controls.

The overall marginal effect of MPU, according to our estimation model, can be calculated as β_1+ β_3*KC where $\beta_1 = -3.134$ and $\beta_3 = 3.164$. If we compute it at the average level of *KC*, the marginal effect of MPU, on average, is approximately -0.104. To better interpret the results, we plot the distribution of the marginal effect of *MPU* with respect of *KC* in panel (a) of Figure 2. In panel (a), the horizonal border measures *KC*, while the vertical border measures the marginal effect of *MPU*. As it shows, the marginal effect of U.S. MPU on the RMB basis is almost always below the zero line; that is, U.S. MPU negatively affects the RMB basis regardless of the level of capital control. However, the negative marginal effect declines as *KC* tightens up – China's capital controls limit cross-border shock transmission and effectively lower the spillover effect of U.S. MPU. Indeed, the marginal effect is attenuated from approximately -0.6 to almost zero when China's capital control level increases from 0.8 to 1.

Regarding how capital controls affect the RMB basis, our model results indicate that capital controls cause a significantly lower RMB basis, which is consistent with the literature findings that capital controls drive deviations from CIP[8] (Dooley and Isard, 1980; Ito, 1983; Cheung and Qian, 2011). However, the direction and degree of the marginal effect depend on the magnitude of U.S. MPU shocks – China's capital controls negatively affect the RMB basis when the U.S. MPU level is lower than 4.7 (about the mean of *MPU*) while they drive up the RMB basis when the U.S. MPU level is higher than its mean [see panel (b) of Figure 2]. This result may reflect the role of capital controls in isolating adverse external shocks (Zeev, 2017), which becomes more prominent as the magnitude of external shocks increases.

To ensure robustness, we use different capital control measures, including Chen and Qian's (2016) capital control index and index of controls on capital inflows (*KCi*) and outflows (*KCo*). Our results hold when using *KCi* and *KCo* (see columns 2 and 3) developed by Fernández et al. (2016) and when using Chen and Qian's (2016) capital controls index (see columns 4-6). In sum, our results suggest that U.S. MPU creates spillover effects and negatively affects the RMB basis. Such a spillover effect is attenuated by capital controls that may limit the transmitting channel of U.S. MPU on the RMB basis. Compared to past works, our study reveals an important role of capital controls rarely discussed in the literature: while it is commonly understood that capital controls limit the mobility of cross-border arbitrage capital, driving a deviation from CIP, the literature seems to neglect the fact that capital controls are able to insulate external shocks (i.e., U.S. MPU shocks) and mitigate the negative effect of external shocks on a cross-currency basis.

3.2.2. RMB exchange rate regime

Cross-border capital flows appear to be a key channel through which global financial shocks transmit to financially open EMEs (Obstfeld et al., 2019). Mundell-Fleming's trilemma paradigm postulates that a country must adopt a flexible exchange rate to maintain monetary autonomy in the presence of free capital mobility. The remarkable rise in cross-border capital

[8] Assuming that CIP holds initially (e.g. RMB basis = 0), a tighter capital control causes the RMB basis to be negatively deviate from CIP (e.g. RMB basis becomes -.05).

flows in EMEs in recent decades has induced macroeconomic policies of many EMEs to shield against external financial shocks with exchange rate flexibility. However, the frequent boom-bust cycle of capital flows has raised doubts about the capacity for flexible exchange rates to insulate EMEs from financial shocks from central countries. Consequently, a growing literature has examined whether flexible exchange rates insolate EMEs from external spillovers and ensure their monetary policy independence. Many works such as Frankel et al. (2004) and Obstfeld et al. (2005) find evidence that emerging economies' short-term interest rates tend to be less correlated with center country interest rates under flexible exchange rate regimes than pegged exchange rate regimes. By contrast, Rajan (2014) argue that in the presence of external shocks, flexible exchange rates sometimes magnify rather than equilibrating such shocks. Indeed, Edwards (2015) finds that policy rates in Latin American countries with flexible exchange rates are strongly affected by monetary policy changes made in the U.S. Recently, Rey (2015) and Miranda-Agrippino and Rey (2015) have proposed a "dilemma, not trilemma" whereby monetary policy autonomy is possible only when capital accounts are managed regardless of exchange rate regimes, suggesting that exchange rate regimes may not necessary play an isolating role.

The question is, with China's capital controls and relatively independent monetary policy making process (Cheung et al., 2008), does China's exchange rate regime cushion shocks from U.S. MPU? The results given in Table 3 indicate that it does not. Rather, it magnifies the spillover effect of U.S. MPU on the RMB basis. As shown in column 1, where the *Fine* index of Ilzetzki et al.'s (2019) measure of exchange regimes is used, β_3 is estimated as negative and significant. Specifically, the negative marginal effect of U.S. MPU on the RMB basis increases to -0.084 when the RMB exchange rate becomes one unit more flexible. The overall marginal effect of U.S. MPU is gauged by $\beta_1 + \beta_3 * Fine$. It is clear that the overall marginal effect of U.S. MPU depends on the RMB exchange rate and that as RMB becomes more flexible, U.S. MPU has more (negative) spillover effects on the RMB basis. Their exact relationship is plotted in panel (a) of Figure 3. When taking current RMB exchange rate flexibility (*Fine* =3) as an example, the estimated marginal effect of U.S. MPU is approximately -0.22, indicating that a 1 standard deviation shock to U.S. MPU lowers the RMB basis by approximately 1.2 percent of the annual percentage rate.

Similar results are estimated when alternative measures for the RMB exchange regime, *Reform* and *Rgm libl,* are used; however, *Reform* and its interaction term with *MPU* reaches 10% level significance. We do not estimate significant coefficients for *Coarse* measurement (see column 2 of Table 3). Although the evidence is not statistically strong, the results may show that how the RMB exchange rate regime limits U.S. MPU spillover may depend on how the RMB exchange regime is measured. In addition, the level of RMB exchange rate flexibility determines the statistical significance of the estimated *MPU* marginal effect. Panels (c), (e), and (g) show that the marginal effect of U.S. MPU is significantly negative when the RMB exchange rate regime is at its highest level, whereas it is insignificant for the pegged exchange rate regime (*RMB rgm* = 0) regardless of exchange rate regime measurements used. Apparently, the model with the RMB exchange regime alone offers us some results, but it does not offer clear-cut evidence for how the RMB exchange regime influences U.S. MPU spillovers. We return to this issue while collectively exploring capital controls, exchange rate regimes, and international reserves in the following subsection.

3.2.3. International reserves

EMEs' central banks' active reserve management that accumulates reserves in good times while selling during crises provides buffer stock as protection from adverse external shocks, bolstering macroeconomics and financial performance (Dominguez et al, 2012; Aizenman and Jinjarak, 2020). To evaluate how reserve management protects China against U.S. MPU shocks on the RMB basis, we add *reserves* and *reserves* × *MPU* to equation (2) and report results in column 1 of Table 4.

As expected, we find that reserves have a buffer stock effect and alleviate the impact of U.S. MPU on the RMB basis. β_3 is estimated as 6.548 at the 1% significance level. In fact, reserves not only mitigate the impact of U.S. MPU spillovers, but they also reverse the direction of U.S. MPU marginal effects when the central bank accumulates high enough reserves. Panel (a) of Figure 4 shows that when reserves increase by more than 0.04 (approximately 4 billion U.S. dollars of monthly foreign exchange reserve accumulation), U.S. MPU effects become positive. It is likely that high enough reserve accumulation ensures investors that China's central bank has enough ammunition to defend against the RMB exchange rate and to provide domestic financial system stability when facing adverse external uncertainty shocks, thus increasing the

RMB basis. Indeed, *Reserves* have a stronger positive effect on the RMB basis when U.S. MPU worsens [see panel (b) of Figure 4].

After examining how capital controls, exchange rate regimes, and reserves influence U.S. MPU spillover effects individually, we include all of them together in one regression to assess how they influence the spillover effect of U.S. MPU on the RMB basis collectively. The results of a regression using the *KC* index developed by Fernández et al. (2016) and the *Fine* exchange regime measure developed by Ilzetzki et al. (2019) are reported in column 2 of Table 4, and corresponding marginal effect plots are presented in panels (c) – (h) of Figure 4.

The regression produces similar results for *reserves*, *KC*, and their interaction term with *MPU*. However, the estimation for *RMB rgm* becomes insignificant in the presence of *reserves* and *KC*. To test the consistency of results, we replace *Fine* with *Coarse*, *Reform*, and *Rgm libl* (see columns 3 -5). *RMB rgm* remains insignificant irrespective of its measurements. Similarly, the effect of *reserves* becomes insignificant when *Coarse*, *Reform*, and *Rgm libl* are used to measure the RMB exchange regime. KC is the only variable that is consistently significantly estimated. These results suggest that *KC* might be the only factor that significantly influences the marginal effect of U.S. MPU on the RMB basis. This finding appears to be in line with Rey's (2015) argument that "independent monetary policies are possible if and only if the capital account is managed."

3.3. Additional analyses

In addition to transmitting shocks through the channel of cross-border capital flows, U.S. MPU might affect the RMB basis by changing the balance of supply and demand for the FX hedge market (e.g., the RMB NDF market) and shift the RMB basis. Indeed, regarding FX hedge demand, Borio et al. (2018) find a change in hedging demand and tighter limits on arbitrage fuel deviations from CIP; on the supply side, Iida et al. (2019) show that the participation of real money investors as suppliers of U.S. dollars in the FX swap market significantly affects deviations from CIP. Du et al. (2018) similarly attribute persistent CIP deviations to the combination of constraints on financial intermediaries and persistent imbalances in investment demand and to finding supply across currencies. They find that CIP deviations increase toward quarter-ends because when facing tighter balance sheet constraints and renewed investor attention due to quarterly regulatory filings, banks reduce supplies of FX hedge products.

We investigate how U.S. MPU affects the RMB basis through its effect on the demand and supply of the FX forward or swap market and how FX hedge market liquidity influences the effect of U.S. MPU on the RMB basis. To do so, we create two variables measuring the liquidity of the FX hedge market. First, we use the direct measure of FX forward market liquidity – the bid and ask spread of NDF (*NDF spread*). A high *NDF spread* denotes fewer NDF transactions, shallow liquidity, and a distorted balance of supply and demand for FX hedge funds. When applied in equation (2), the coefficient of *NDF spread* × *MPU* is significant if FX hedge market liquidity influences U.S. MPU spillover.

The other measurement follows Du et al. (2018) by using a quarterly dummy (*Quarter*) to capture the bank regulation effect on FX hedge supply. We set *Quarter* as equal to 1 for February, May, August, and November, which are the months before quarter-ends. For each quarter-end, a one-month forward contract must appear on the quarter-end balance sheet. To circumvent regulation, banks short one-month forward contracts one-month before a quarter ends to reduce the supply of forward contracts and create demand and supply imbalances.

The *NDF spread* and *Quarter* results are reported in Table 5 and their marginal effects on the RMB basis are plotted in Figure 5. As expected, a shallow NDF market not only reduces the RMB basis directly [see panel (b)] but also magnifies the spillover effect of U.S. MPU to further reduce the RMB basis (see column 1 of Table 5 and panel (a) of Figure 5). On the other hand, *Quarter* and its interaction terms with *MPU* are not significant, which is likely for two reasons. First, a quarter dummy may be too coarse to reflect the true supply of forward contracts from banks. Second, the RMB NDF market is relatively small compared to other FX hedge markets (e.g., swap markets). Banks do not necessarily adjust their positions on RMB NDF in quarter-ends to avoid bank regulations.

The 2008 global financial crisis (GFC) seems to have changed the landscape of CIP. CIP was largely held among the world's major currencies before the GFC, but it has been persistently violated since the GFC (Du et al., 2018; Avdjiev et al., 2019). We examine if the same applies to RMB CIP and if it does, how the GFC has changed the spillover of U.S. MPU on the RMB basis. The GFC reflects a major shift in U.S. monetary policy and spurred stricter government regulations on bank liquidity risk directly affecting banks' supplies for FX hedge market funds.

It would be informative to examine how U.S. MPU may have affected the RMB basis differently before and after the GFC. We create a simple time dummy to proxy the GFC (i.e., *GFC* = 1 if month >= Sept. 2008; 0, otherwise). The results are reported in column 3 of Table 5. Two points stand out: first, the RMB basis grows after 2008 GFC; second, U.S. MPU has no significant effect on the RMB basis before the 2008 GFC. However, since the GFC, it has a noticeably greater effect on the RMB basis compared to that estimated in Table 1 – a 1 standard deviation shock from U.S. MPU reduces the RMB basis by approximately 0.08 percent (approximately 0.03 in Table 1). These results hold when we add *NDF spread*, *Quarter*, and *GFC* and their interaction terms with *MPU*, except that the estimation for *NDF spread* and interaction terms with *MPU* become less significant. Overall, our findings are consistent with those of Du et al. (2018) and Avdjiev et al. (2019) and may show that RMB is to some degree integrated into the global financial market and is affected by global dollar fund shortfalls.

4. Concluding remarks

The FX forwards and swap market is one of the largest and most liquidity FX derivative markets in the world. This market enables covered interest rate parity (CIP) to hold in the presence of free capital mobility. However, CIP among the world's major currencies has been systematically and persistently violated since the 2008 global financial crisis, mainly because renewed and more restrictive regulatory environments post-crisis have created renewed constraints on financial intermediaries and persistent imbalances in global funds to demand and supply foreign currencies and FX hedge contracts.

CIP in emerging markets is generally not held due to the presence of capital controls or the combination of capital controls and peg/managed exchange rate regimes. Do persistent imbalances of global funds affect CIP in EMEs' currencies as well? If it does, through what channel does this global fund imbalance impact EMEs' CIP? This paper attempts to answer these questions by examining the Chinese currency, RMB, as an example and by using U.S. MPU, a global factor closely associated with the imbalance of global funds in FX markets, to represent the level of global funds imbalance.

Our findings suggest that U.S. MPU has a statistically and economically significant effect on the RMB basis, the measurement for deviations from RMB CIP. In particular, shocks in U.S. MPU create a global U.S. dollar shortfall, which induces a shift in cross-border capital outflows to seek for offshore investment returns and a reduction in the RMB basis. The finding is accordance with the postulation that U.S. MPU imposes spillover effects on the RMB basis by transmitting a shock wave through cross-border capital flows. Thus, any policy or macro condition that constrains the transmitting channel may change the impact of U.S. MPU on the RMB basis. We examine three plausible constraints, namely, capital controls, the RMB exchange rate regime, and international reserves, and analyze how they influence the effect of U.S. MPU. We find some evidence that a more flexible but still managed RMB exchange rate regime is exacerbated while international reserves ameliorate the negative spillover effect of U.S. MPU on the RMB basis. However, when combined with capital controls, effects of the RMB exchange regime and international reserves fade. It is capital controls that consistently reduce the spillover effect of U.S. MPU by effectively limiting the transmission of U.S. MPU shocks. The finding points to a trade-off between capital controls serve as a Tobin tax that creates CIP deviations and mitigate external shocks to reduce deviations from CIP.

Although focusing on China, our study is of relevance in terms of macroeconomic stability for all EMEs. As it does in China, U.S. MPU may drive deviations from CIP in other EMEs by inducing cross-border capital flows. Volatile cross-border capital flows may cause “sudden stops” and financial crises that devastate EMEs real macroeconomy. Future researches are necessary to understand how the spillover effect from policy uncertainties in central countries affects CIP in all EMEs.

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Appendix A: variable definitions and data sources

Variable	Definition	Source
Basis	1-month RMB cross-currency basis, in %, equals to (r-r*)/(1+r*) – (F-S)/S, where r is the Chinese interbank offer rate (CHIBOR), r* is the US$ LIBOR, F is the RMB NDF 1-month rate, and S is the spot exchange rate (yuan/$).	Bloomberg and authors' calculation
MPU	Baker-Bloom-Davis Monetary Policy Uncertainty Indices for the United States (10 major papers), in ln.	https://www.policyuncertainty.com (Jan 1999-June 2020)
VIX	CBOE Volatility Index, in ln difference	CBOE
Fed rate	The Wu and Xia (2016) U.S. Federal funds shadow rate	Wind
Capital controls		
KC	Overall restrictions index (all asset categories)	Fernández et al. (2016): Jan 1999-Dec 2018; Chen and Qian (2016): Jan 1999-Dec 2016
KCi	Overall inflow restrictions index (all asset categories)	Fernández et al. (2016); Chen and Qian (2016)
KCo	Overall outflow restrictions index (all asset categories)	Fernández et al. (2016); Chen and Qian (2016)
Exchange rate regime		
Fine	Fine=0, January 1999-December 2005; Fine=1, January 2006-December 2013; Fine=3, January 2014-present	Ilzetzki, Reinhart and Rogoff (2019)
Coarse	Coarse=0, January 1999-December 2005 and Coarse=1 January 2006-present	Ilzetzki, Reinhart and Rogoff (2019)
Reform	Reform=0, January 1999-June 2005; Reform=1, July 2005 and July 2015; Reform=2, August 2015-present	
Rgm libl	Regime=0, January 1999-June 2005, when daily trading band for the USD/CNY rate sets at ±0.3%	
	Regime=1, July 2005-April 2007, after exchange rate reform	
	Regime=2, May 2007-March 2012, when daily trading band for the USD/CNY rate sets at ±0.5%	

	Regime=3, April 2012-February 2014, when daily trading band for the USD/CNY rate sets at ±1%	
	Regime=4, March 2014-July 2015, when daily trading band for the USD/CNY rate sets at ±2%	
	Regime=5, August 2015 -present, when China upgrades the mechanism of USD/CNY central parity rate formation: the daily central parity quotes reported to the China Foreign Exchange Trade System (CFETS) before the market opens should be mainly based on the closing rate of the inter-bank foreign exchange market on the previous day, and make minor adjustment according to the price movements of major currencies, foreign exchange supply and demand on the previous day.	
International reserves		
Reserves	China international reserves excluding gold (Hundreds of Millions U.S. Dollar), in natural log difference	DataStream
FX hedge market		
NDF spread	Average monthly difference of bid and asking price of RMB NDF, calculated from daily data.	Bloomberg
Quarter	equals to 1 if month = February, May, August, and November.	
GFC	Equals to 1 if month >= Sept. 2008.	
Control variables		
M2	China's M2 to GDP ratio, first difference	PBOC
Inflation	China's inflation calculated as ln difference of CPI, CPPY=100 (Current period previous year).	Wind
Trade open	China’s trade openness, total trade as a percentage of GDP, first difference. Monthly GDP data is extrapolated using quarterly GDP data on monthly industrial production data.	DataStream and authors calculation
NEER	RMB nominal effective exchange rate, 2010 = 100, in ln difference	BIS

Appendix B: Summary statistics

	Obs.	Mean	Std. Dev.	Min	Max
CID	258	0.1258	0.4321	-0.7341	1.8537
MPU	258	4.7647	0.4626	3.7920	6.1965
VIX	258	2.9265	0.3623	2.3150	4.1373
Fed rate	258	1.4131	2.4474	-2.99	6.65
M2	252	19.5833	3.5953	12.8756	33.5790
Inflation	258	4.6257	0.0204	4.58292	4.6885
Trade open	252	0.0623	0.0136	0.0325	0.0910
NEER	258	102.8226	11.9166	83.95	126.54
KC (Fernández et al. 2016)	228	0.9578	0.0694	0.8	1
KC (Chen and Qian, 2016)	216	3.7251	1.0325	1.1388	5.31
Reserves	257	.0119	.0172	-.0415	.0611
NDF spread	258	.0069	.0062	0	.0465
Fine	258	1.2790	1.2094	0	3
Coarse	258	0.6744	0.4695	0	1
Reform	258	0.9263	0.7263	0	2
Rgm libl	258	2.2170	1.9163	0	5

Table 1: U.S. monetary policy uncertainty and RMB cross-currency basis

	1	2	3	4	5	6
Basis(-1)	0.849***	0.857***	0.840***	0.857***	0.865***	0.847***
	(0.032)	(0.032)	(0.034)	(0.032)	(0.032)	(0.034)
MPU	-0.060**			-0.067**		
	(0.030)			(0.031)		
VIX		-0.138*			-0.152*	
		(0.078)			(0.087)	
Fed rate			-0.010*			-0.010
			(0.006)			(0.006)
M2				0.009*	0.010*	0.008
				(0.005)	(0.005)	(0.005)
Inflation				-0.092	0.758	0.785
				(2.451)	(2.455)	(2.460)
Trade Open				-2.729	-2.882	-1.307
				(4.159)	(4.192)	(4.173)
NEER				-0.037***	-0.033***	-0.035***
				(0.012)	(0.012)	(0.012)
Constant	0.304**	0.019	0.035**	0.342**	0.021	0.038**
	(0.145)	(0.014)	(0.017)	(0.150)	(0.015)	(0.018)
Obs.	257	257	257	251	251	251
Adj. R^2	0.738	0.737	0.737	0.747	0.746	0.745

Note: this table reports results of ARDL regression. The RMB cross-currency basis is the dependent variable. Robust standard errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 2: U.S. monetary policy uncertainty, capital controls, and RMB cross-currency basis

	1	2	3	4	5	6
Basis(-1)	0.825***	0.834***	0.816***	0.806***	0.812***	0.811***
	(0.032)	(0.032)	(0.032)	(0.036)	(0.035)	(0.037)
MPU	-3.134***	-2.941***	-3.212***	-0.699***	-0.663***	-0.445***
	(0.494)	(0.488)	(0.494)	(0.138)	(0.123)	(0.107)
M2	0.011**	0.011**	0.011*	0.008	0.008	0.008
	(0.005)	(0.005)	(0.005)	(0.006)	(0.006)	(0.006)
Inflation	0.067	0.115	-0.022	0.318	0.278	0.316
	(2.413)	(2.433)	(2.400)	(2.611)	(2.597)	(2.651)
Trade Open	-2.133	-2.523	-1.779	-1.723	-1.296	-2.279
	(4.125)	(4.156)	(4.106)	(4.433)	(4.410)	(4.506)
NEER	-0.051***	-0.050***	-0.051***	-0.047***	-0.048***	-0.043***
	(0.012)	(0.013)	(0.012)	(0.013)	(0.013)	(0.013)
KC	-15.128***			-0.808***		
	(2.423)			(0.175)		
KC×MPU	3.164***			0.161***		
	(0.512)			(0.036)		
KCi		-14.109***			-0.756***	
		(2.388)			(0.153)	
KCi×MPU		2.970***			0.151***	
		(0.506)			(0.031)	
KCo			-15.530***			-0.532***
			(2.415)			(0.148)
KCo×MPU			3.236***			0.106***
			(0.510)			(0.031)
Constant	15.017***	13.997***	15.448***	3.520***	3.343***	2.250***
	(2.343)	(2.304)	(2.341)	(0.686)	(0.616)	(0.521)
Obs.	227	227	227	215	215	215
Adj. R^2	0.790	0.786	0.792	0.776	0.778	0.769

Note: this table reports results of ARDL regression. The RMB cross-currency basis is the dependent variable. Columns 1-3 report results based on capital controls index from Fernández et al. (2016) and columns 4 - 6 are based on Chen and Qian (2016) capital control index. KCi is control on capital inflows and KCo measures capital outflows control. Robust standard errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 3: U.S. monetary policy uncertainty, RMB exchange rate regime, and RMB cross-currency basis

	1	2	3	4
Basis(-1)	0.836***	0.845***	0.856***	0.845***
	(0.032)	(0.033)	(0.032)	(0.032)
MPU	0.030	-0.016	0.016	0.028
	(0.047)	(0.059)	(0.054)	(0.049)
M2	0.009*	0.009*	0.009*	0.009*
	(0.005)	(0.005)	(0.005)	(0.005)
Inflation	0.016	-0.166	-0.124	-0.048
	(2.400)	(2.442)	(2.443)	(2.418)
Trade Open	-1.735	-2.396	-2.555	-2.203
	(4.089)	(4.160)	(4.156)	(4.118)
NEER	-0.042***	-0.038***	-0.040***	-0.042***
	(0.012)	(0.012)	(0.012)	(0.012)
Fine	0.416***			
	(0.123)			
Fine×MPU	-0.084***			
	(0.026)			
Coarse		0.481		
		(0.326)		
Coarse×MPU		-0.093		
		(0.070)		
Reform			0.409*	
			(0.209)	
Reform×MPU			-0.085*	
			(0.043)	
Rgm libl				0.230***
				(0.079)
Rgm libl×MPU				-0.046***
				(0.016)
Constant	-0.130	0.078	-0.048	-0.113
	(0.217)	(0.271)	(0.252)	(0.230)
Obs.	251	251	251	251
Adj. R^2	0.758	0.750	0.749	0.754

Note: this table reports results of ARDL regression. The RMB cross-currency basis is the dependent variable. RMB rgm is measured by fine and coarse measurements for RMB exchange rate regime from Ilzetzki et al. (2019), exchange rate reform at July 2005 time dummy (*Reform*), and the rank variable for RMB exchange rate evolution (*Rgm libl*) in columns 1 - 4, respectively. Robust standard errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 4: U.S. monetary policy uncertainty, international reserves, capital controls, RMB exchange rate regimes, and the RMB cross-currency basis

	1	2	3	4	5
Basis(-1)	0.858***	0.799***	0.805***	0.814***	0.812***
	(0.031)	(0.033)	(0.033)	(0.032)	(0.032)
MPU	-0.146***	-3.308***	-2.881***	-3.213***	-3.574***
	(0.038)	(0.922)	(0.636)	(0.712)	(0.863)
M2	0.010*	0.010*	0.011**	0.011**	0.011**
	(0.005)	(0.005)	(0.005)	(0.005)	(0.005)
Inflation	0.304	0.301	0.263	0.240	0.293
	(2.385)	(2.386)	(2.398)	(2.409)	(2.399)
Trade Open	-4.439	-2.631	-2.316	-2.692	-2.496
	(4.063)	(4.124)	(4.152)	(4.163)	(4.146)
NEER	-0.036***	-0.037***	-0.044***	-0.040***	-0.039***
	(0.012)	(0.013)	(0.013)	(0.014)	(0.013)
Reserves	-30.192***	-18.235*	-13.944	-15.304	-16.921
	(7.814)	(10.316)	(10.018)	(10.349)	(10.356)
Reserves*MPU	6.548***	4.338*	3.319	3.645	4.037*
	(1.645)	(2.218)	(2.136)	(2.223)	(2.225)
KC		-14.695***	-13.366***	-14.859***	-16.242***
		(4.386)	(3.126)	(3.375)	(4.064)
KC×MPU		3.197***	2.779***	3.115***	3.451***
		(0.920)	(0.661)	(0.720)	(0.858)
RMB rgm		-0.227	-0.353	-0.321	-0.200
		(0.273)	(0.362)	(0.325)	(0.161)
RMB rgm×MPU		0.063	0.091	0.078	0.048
		(0.058)	(0.078)	(0.070)	(0.034)
Constant	0.715***	15.171***	13.801***	15.286***	16.775***
	(0.183)	(4.386)	(3.005)	(3.329)	(4.077)
Obs.	251	227	227	227	227
Adj. R^2	0.762	0.795	0.793	0.792	0.793

Note: this table reports results of ARDL regression. The RMB cross-currency basis is the dependent variable. KC is capital controls index from Fernández et al. (2016). Columns 2, 3, 4, and 5 reports results when RMB rgm is measured by *Fine* and *Coarse* measurements for RMB exchange rate regime from Ilzetzki et al. (2019), exchange rate reform at July 2005 time dummy (*Reform*), and the rank variable for RMB exchange rate evolution (*Rgm libl*), respectively. Robust standard errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Table 5: U.S. monetary policy uncertainty, NDF market liquidity, and the RMB cross-currency basis

	1	2	3	4
Basis(-1)	0.852***	0.860***	0.845***	0.844***
	(0.033)	(0.032)	(0.032)	(0.032)
MPU	0.036	-0.060	0.013	0.084
	(0.061)	(0.038)	(0.048)	(0.069)
M2	0.010*	0.012**	0.009*	0.012**
	(0.005)	(0.005)	(0.005)	(0.005)
Inflation	-0.116	0.033	-0.004	0.111
	(2.423)	(2.434)	(2.420)	(2.387)
Trade Open	-4.463	-2.626	-2.691	-3.740
	(4.168)	(4.131)	(4.131)	(4.117)
NEER	-0.034***	-0.036***	-0.037***	-0.035***
	(0.012)	(0.012)	(0.012)	(0.012)
NDF Spread	97.307*			86.229
	(50.847)			(52.939)
NDF Spread×MPU	-22.898**			-20.182*
	(11.131)			(11.627)
Quarter		0.093		0.140
		(0.315)		(0.310)
Quarter×MPU		-0.035		-0.044
		(0.066)		(0.065)
GFC			0.876***	0.663**
			(0.313)	(0.321)
GFC*MPU			-0.178***	-0.130*
			(0.066)	(0.068)
Constant	-0.097	0.330*	-0.039	-0.323
	(0.283)	(0.181)	(0.221)	(0.321)
Obs.	251	251	251	251
Adj. R^2	0.753	0.751	0.754	0.761

Note: this table report results of ARDL regression. The RMB cross-currency basis is the dependent variable. Quarter is the time dummy variable measuring the month before quarter end month (i.e. Feb., May, Aug., and Nov.). GFC measures 2008 global financial crisis (GFC = 1 if month >= Sept. 2008; otherwise =0). Robust standard errors are in parentheses. ***, **, * denote for 1%, 5% and 10% significance.

Figure 1: U.S. MPU index and the VIX index

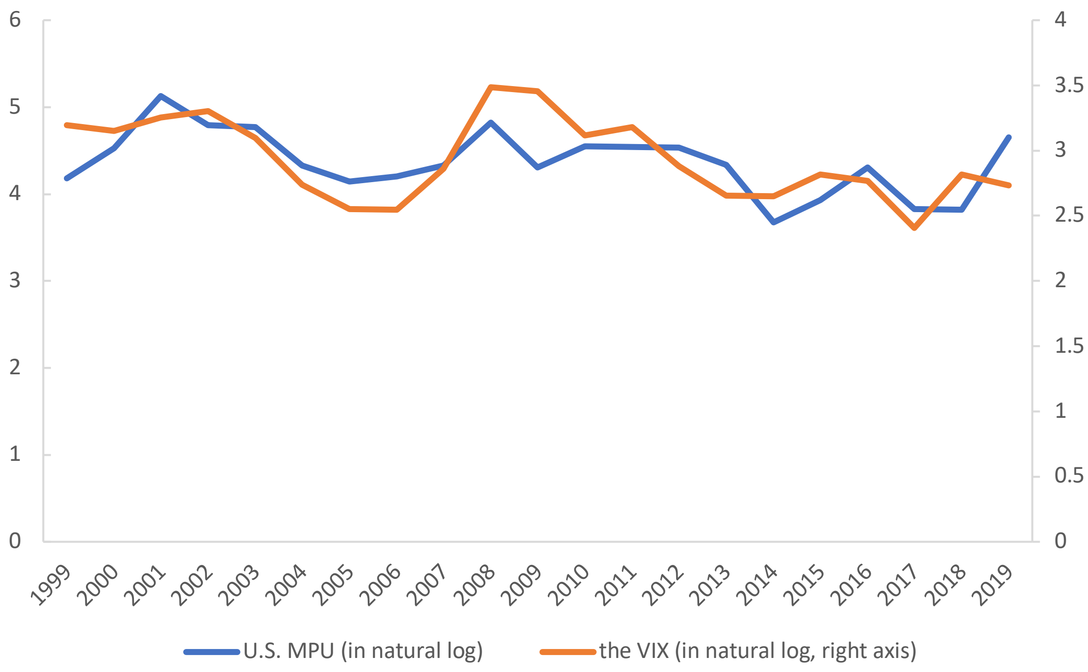
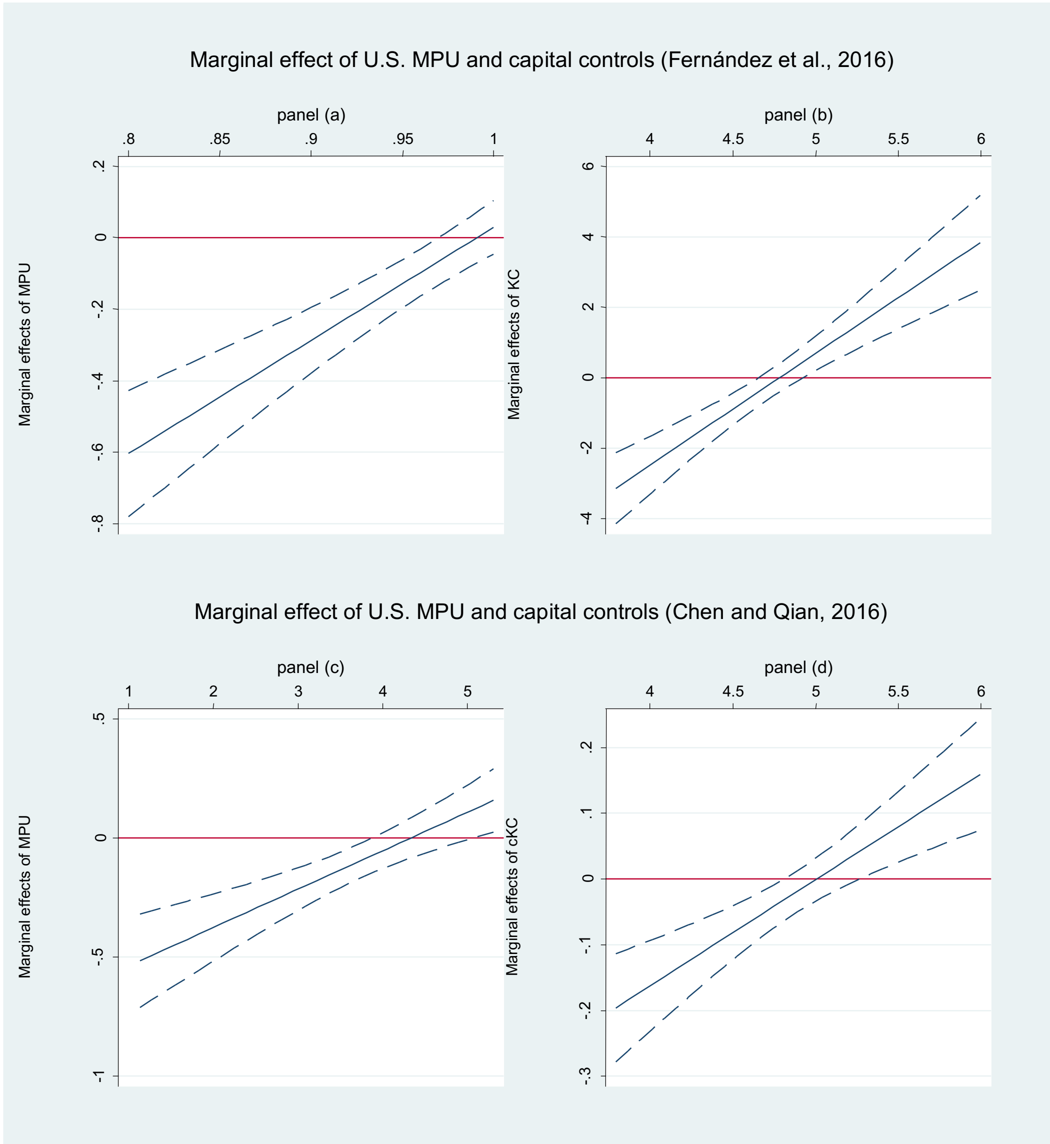
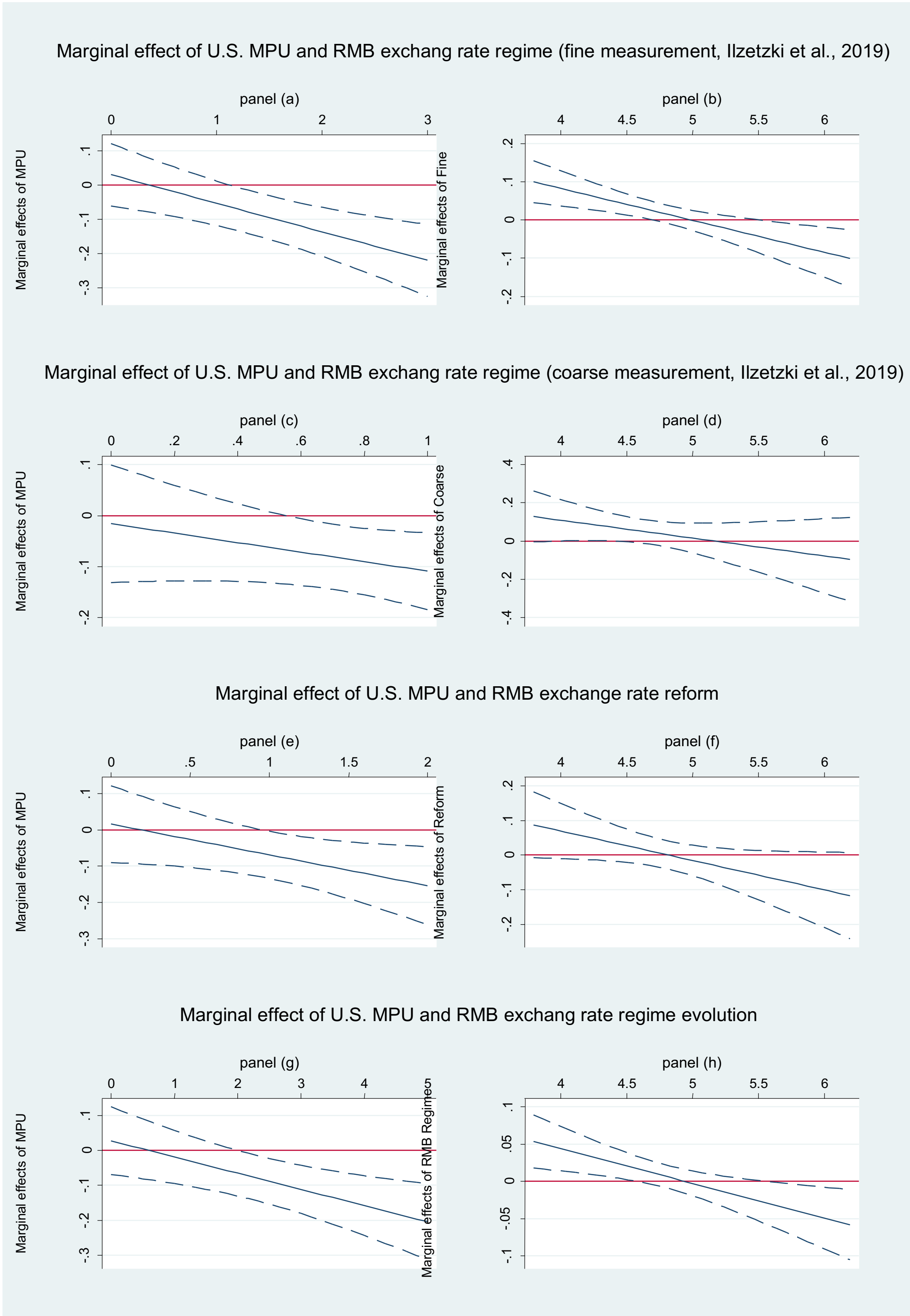


Figure 2: The marginal effect of U.S. MPU and capital controls on RMB cross-currency basis



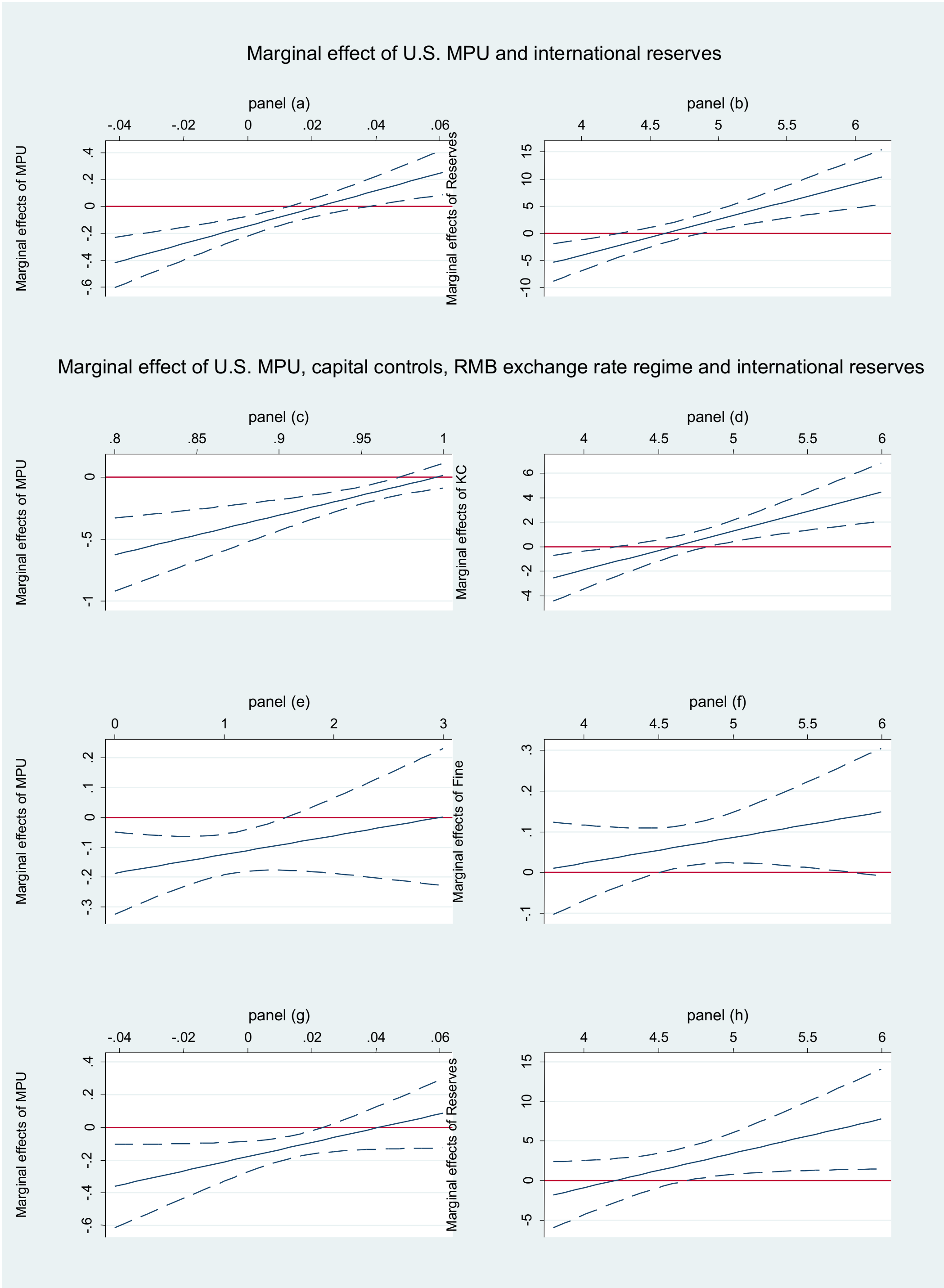
Notes: This figure plot the marginal effect of U.S. MPU and China's capital controls on RMB cross-currency basis based on results in columns 1 and 4 of Table 3. Dash lines mark 95% confidence intervals.

Figure 3: The marginal effect of U.S. MPU and RMB exchange rate regime on RMB cross-currency basis



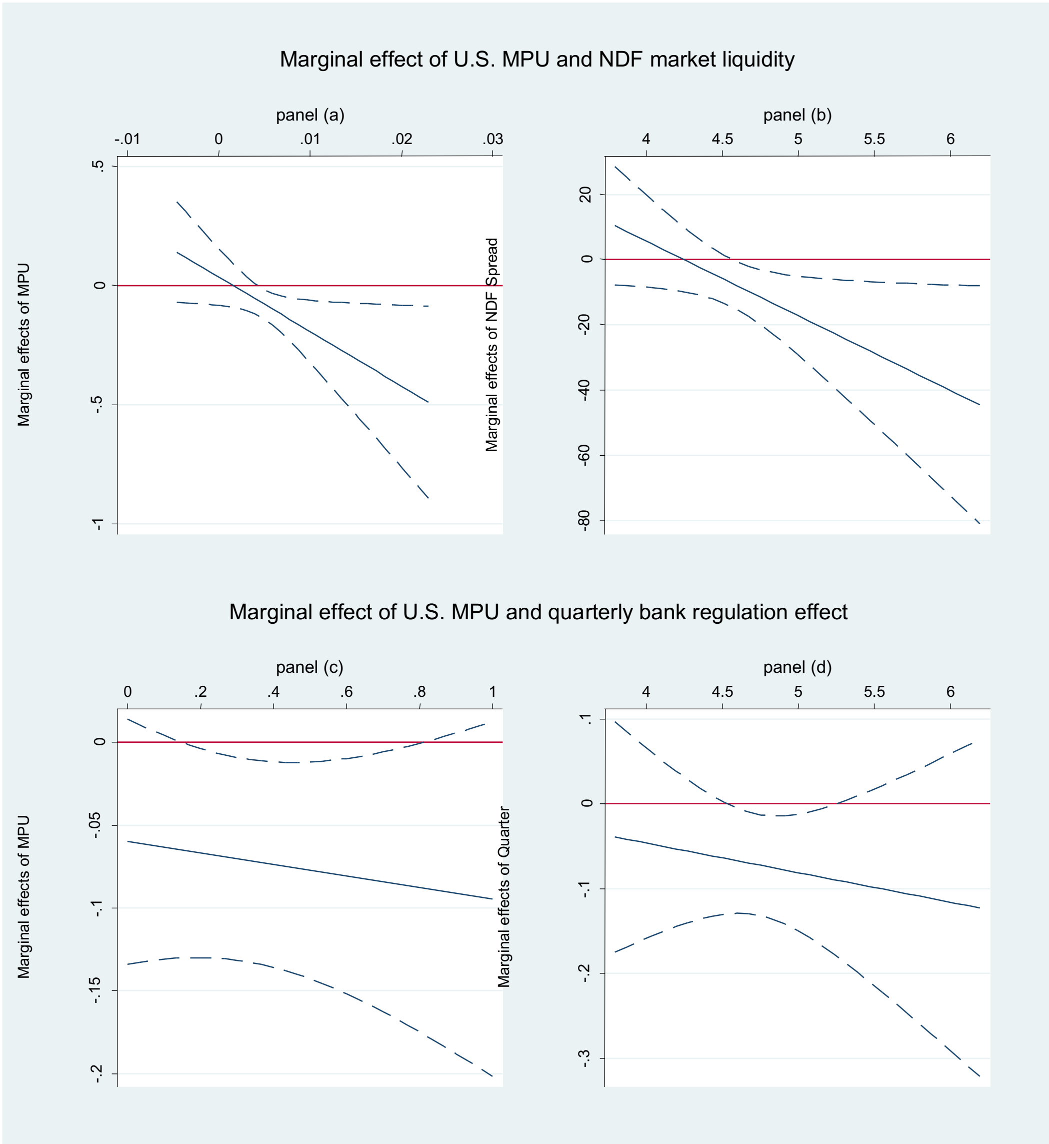
Notes: This figure plot the marginal effect of U.S. MPU and RMB exchange rate regime on RMB cross-currency basis based on results in columns 1 to 4 of Table 4. Dash lines mark 95% confidence intervals.

Figure 4: The marginal effect of U.S. MPU, international reserves, capital controls, RMB exchange rate regime on RMB cross-currency basis



Notes: This figure plot the marginal effect of U.S. MPU, international reserves, capital controls, RMB exchange rate regime on RMB cross-currency basis based on results in columns 1 and 2 of Table 5. Dash lines mark 95% confidence intervals.

Figure 5: The marginal effect of U.S. MPU and NDF market liquidity on RMB cross-currency basis



Notes: This figure plot the marginal effect of U.S. MPU and NDF market liquidity on RMB cross-currency basis based on results in columns 1 and 2 of Table 6. Dash lines mark 95% confidence intervals.