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# Convertibility restriction in China's foreign exchange market and its impact on forward pricing

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# Contents

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## Abstract

In contrast to the well established markets such as the dollar-euro market, recent CIP deviations observed in the onshore dollar-RMB forward market were primarily caused by conversion restrictions in the spot market rather than by changes in credit risk and/or liquidity constraint. This paper proposes a theoretical framework by which the Chinese authorities impose conversion restrictions in the spot market in an attempt to achieve capital flow balance, but face the tradeoff between achieving such balance and disturbing current account transactions. Consequently, the level of conversion restriction should increase with the amount of capital account transactions and decrease with the amount of current account transactions. Such conversion restriction in turn places a binding constraint on forward traders' ability to cover their forward positions, resulting in the observed CIP deviation. More particularly, the model predicts that the onshore forward rate will equal a weighted average of the CIP-implied forward rate and the market's expectation of the future spot rate, were the weighting is determined by the level of conversion restriction. As a secondary result, the model also implies that offshore non-deliverable forwards reflect the market's expectation of the future spot rate. Our empirical results are consistent with these predictions.

Keywords: forward foreign exchange, China, convertibility
JEL: F30, F31, F33.

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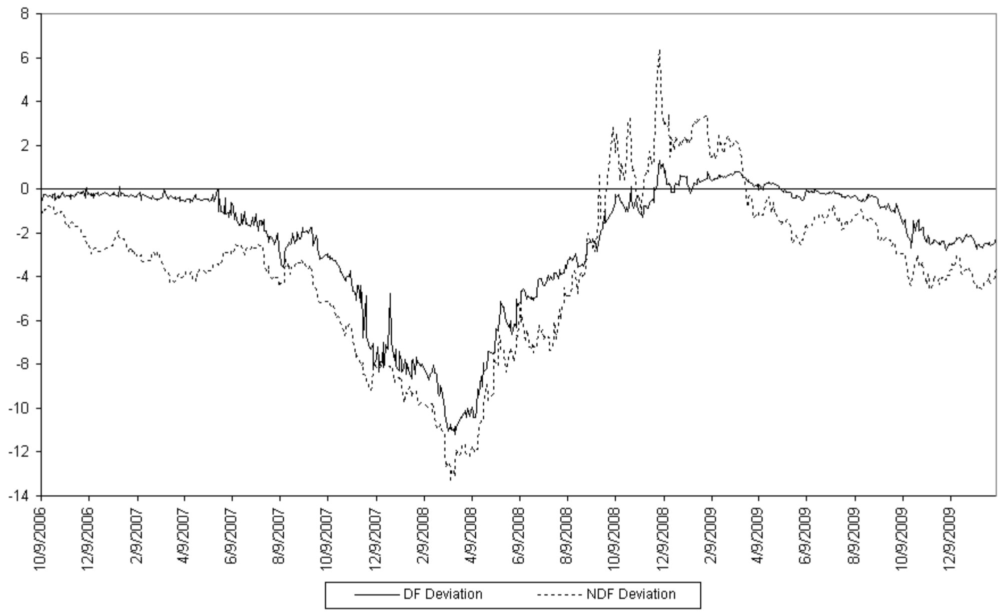
# 1 Introduction

Relative to the offshore retail dollar-RMB forward market, China's young onshore interbank foreign exchange forward market has received surprisingly little academic attention since its establishment in October 2005. Although the transaction volume data for this interbank market have been elusive up to this point, there are reasons to believe that a great deal of money is at stake. For example, according to an estimate in 2004, even the offshore forward market between the RMB and U.S. dollar had typical daily volumes of about $150 to 200 million and exhibited an upward trend toward $600 million (Fung et al. 2004): Thus one has might well expect that the daily trading volume for the onshore interbank market would even exceed $600 million. In fact, anecdotal evidence suggests that the daily trading volume of the onshore forward market could be well over $1 billion. Given that both the onshore and offshore markets are deeply connected in the sense that many participants are highly active in both markets, it is essential to focus on both markets rather than just one so as to gain a more comprehensive understanding of the dollar-Yuan forward markets.

Besides the amount of money involved in the forward markets, another important reason that economists should pay more attention to the dollar-yuan forward markets in general – and the onshore market in particular – is that disturbances in the forward market can have real impacts on international trade activities. This is because forward contracts are one of the main tools importers and exporters use to hedge exchange rate uncertainties. Finally, Chinese monetary policy makers should also pay closer attention to the forward markets because deviations from CIP can have significant impacts on the direction and magnitude of capital flows into or out of China. In this light, this paper attempts to provide a more complete picture of the dollar-yuan forward markets, both onshore and offshore.

It has been recently documented that forward prices in the interbank market exhibit persistent violations of covered interest rate parity (CIP) (Wang 2010 and McKinnon et al. 2010). CIP states that the forward price between two currencies should equal the spot rate multiplied by the interest rate differential between the two currencies (i.e. $F = S\frac{1+i_A}{1+i_B}$ where F and S are the forward and spot exchange rate quoted in the units of currency A per unit of currency B). As the CIP formula suggests, if the forward rate deviates from CIP, a trader can in theory realize arbitrage profit by borrowing in one currency, converting the borrowing proceeds into the other currency in the spot market, lending in the other currency, and converting back into the original currency via a forward contract. Figure 1 shows the deviations of forward rates from CIP-implied forward rates for 12-month forwards (both onshore deliverable forwards and offshore non-deliverable forwards) based on the 12-month Libor and 12-month Shibor.

Figure 1 CIP Deviations of 12-month forwards (percentage)




As Figure 1 shows, besides the CIP violations of both onshore and offshore forward prices, there appear to be significant price differences between the onshore-interbank-deliverable forwards (DF) and offshore-retail-non-deliverable forwards (NDF).[1] Both the violations of CIP in the interbank market and the price discrepancies between onshore and offshore forwards appear to generate potential arbitrage opportunities to market participants.[2] In addition, although CIP-violations in both markets do exhibit a high level of positive correlation, it is not immediately obvious that violation in one market is always associated with violation in the other. From Figure 1, we see that prior to May 2007, CIP-violations between the two markets seem not to be highly correlated. However, from May 2007 onward,

[1] The pairings of deliverable contracts to the onshore market and non-deliverable contracts to the offshore market is not arbitrary but derives from the fact that deliverable contracts are only traded onshore whereas the offshore markets involve only non-deliverable contracts.
[2] For the most part in China's case, the deviations reflect arbitraging opportunity involving borrowing in dollars, shorting the dollar in the spot market, lending in RMB, and longing the dollar in the forward market. There appears to be a brief exceptional period, from October 2008 to April 2009, during which the deviations were not only modest in magnitude but reflected arbitrage opportunities in the opposite direction.

the correlation between CIP violations in the two markets clearly increased. This paper argues that offshore CIP violation is a necessary but not sufficient condition for onshore CIP violation, and whether the two markets exhibit CIP violations simultaneously primarily depends on the level of conversion restriction that Chinese foreign exchange authorities impose on the spot market.

Other scholars have previously studied the empirical robustness of CIP, focusing on the past decade and using violations of CIP to gauge the level of financial integration of the EU (Holmes 2000). Until very recently, data on forward markets between currencies of developed countries have reflected the empirical robustness of CIP. High frequency data show that; although CIP deviations indeed occur for currency pairs such as dollar-Euro, dollar-Sterling, and dollar-yen; they are relatively short lived, lasting no more than 15 minutes (Akram et al. 2008). Indeed, such findings are consistent with the notion that any potential arbitrage opportunity in the forward market would be quickly squeezed away.

More recently however, scholars have identified more persistent violations of CIP in well established markets such as the dollar-euro market during the financial turmoil of 2008 (Sarkar 2009, Baba & Packer 2009, Mancini-Griffoli & Ranaldo 2009). Sarkar identified a drastic increase in the magnitude of CIP deviations following the Lehman Brothers bankruptcy in September 2008 in the dollar-euro forward market using dollar Libor and euro Libor, but did not provide a detailed causal explanation. Baba & Packer also identified CIP violations between the dollar and euro over a similar time period in the swap market. Furthermore, they attribute the deviations to differences in counterparty risk between European and U.S. financial institutions. Mancini and Ranaldo (2009) points to liquidity constraints in the dollar money market as the primary cause of the observed CIP deviations. Finally, some scholars contend that CIP violations between currency pairs of developed countries were partly due to liquidity constraints and partly due to heightened counter party credit risk (Coffey et al. 2009).

Unfortunately, the reasons cited for CIP violation in the dollar-euro market do not satisfactorily explain the CIP deviations witnessed in the dollar-RMB market. Three inconsistencies between the dollar-euro market and the dollar-RMB market discredit the notion that CIP violations in the two markets are generated by similar causes:

i. Timing: Timing of CIP deviations between the two markets does not coincide. The dollar-RMB market exhibited CIP deviation much earlier than the dollar-euro market. In addition, when CIP violations in the dollar-euro market were peaked around October 2008, which was shortly after the Lehman bankruptcy, CIP violations in dollar-RMB market had already moderated.

ii. Magnitudes: The magnitudes of CIP deviations between the two markets were also far apart, with the deviation in the dollar-euro market never exceeding 240 basis points according to Sarkar (2009) and deviation in the dollar-RMB market exceeding 1,000 basis points, according to Figure 1.

iii. Direction: Regarding developed markets, scholars have primarily focused their attention on CIP deviations in the months following the Lehman bankruptcy, which was reasonable because the deviations were greatest in magnitude in this period. In particular, the CIP deviations in these markets represent arbitrage opportunities involving shorting the dollar in the spot market (Coffey et al. 2009). CIP deviations in the Chinese market also reflect arbitrage opportunities in the same direction for the most part during my sample period. However, during the months following the Lehman bankruptcy, CIP deviations in the dollar-RMB market were not only moderate in magnitude, but also reflected arbitraging opportunities involving longing the dollar in the spot market, which is opposite in direction to the arbitrage opportunities in the well developed markets.

In light of the above-mentioned inconsistencies, there are reasons to believe that the causes of CIP deviations in the two markets are different and any reasons given to explain CIP deviations in the dollar-euro market probably are not generally convincing if applied to CIP deviations in the dollar-RMB market. Of course, it is possible that, shortly after the Lehman bankruptcy, those factors behind CIP deviations in the well-established markets could also explain the reversal of direction in CIP deviations in the Chinese markets. However, this is not the focus of this paper and will be reserved for another time. The focus here is on the much greater CIP deviations in the Chinese market prior to the Lehman bankruptcy.

For the offshore dollar-RMB NDF market, this paper is not the first to document CIP violations. In fact, CIP deviations in the offshore market were documented as early as 2004 (Ma et. al 2004). CIP violations in the offshore dollar-RMB have also been cited as evidence in support of the efficacy of Chinese capital control policies (Ma & McCauley

2008). In particular, Ma & McCauley argue that the main reason for persistent CIP deviations in the offshore dollar-RMB NDF market between 2004 and 2006 was that participants in this market did not have access to the RMB money market and hence were facing different interest rates from the onshore interest rates used for CIP calculations. However, this particular reason no longer holds because certain participants had access to, and indeed participated heavily in, both the onshore and offshore markets during the period studied in this paper. More recently, scholars have found empirical evidence that CIP deviations in the offshore market are a significant determinant of China's capital flight (Cheung & Qian 2010).

In light of the above, it is surprising that the onshore interbank market has thus far received so little academic attention. In fact, Wang (2010) appears to be the first documentation of CIP violations in the onshore forward market. Wang (2010) hypothesizes that CIP deviations in the onshore market prior to the Lehman bankruptcy were caused by conversion restrictions imposed by the State Administration of Foreign Exchange (SAFE) in an effort to balance capital flows into and out of China. However, although it presented evidence that Chinese authorities indeed impose conversion restrictions in the spot market that coincide with observed CIP deviations, Wang (2010) did not provide a theoretical argument on why conversion restrictions are imposed, how the level of these should be measured, or exactly how conversion restrictions influence forward pricing. This paper attempts to address these shortcomings.

In China's case, SAFE imposes conversion restrictions in the spot market by blocking certain transactions. In particular, SAFE has the legal authority to review all foreign exchange transactions in the interbank market. Consequently, no interbank spot transaction can legally occur without the approval of SAFE. For example, assume that Citi and HSBC have agreed to conduct a spot conversion between dollar and RMB. In order for this trade be realized, both parties must submit proof that their need to carry out the transaction originates from current account activities. If the spot transaction in question originates from capital account activities, then the parties must show that this particular capital account transaction is consistent with the capital control policy. In particular, any conversion transaction originating from capital inflows aimed at taking advantage of anticipated RMB appreciation is high on SAFE's denial list. Unfortunately, a forward trader's attempt to cover his forward position might resemble such a capital inflow in the eyes of SAFE and consequently faces a strictly positive probability of being denied and results in CIP deviation in forward pricing.

The main findings of this paper are: 1) China imposes conversion restrictions to achieve balance in capital flows, but faces the tradeoff against potentially disturbing spot transactions originating from current account activities. In particular, the level of conversion restriction should increase with deviations from uncovered interest rate parity (UIP) and decrease with export or import volumes, depending on the direction of capital flow, 2) When conversion restrictions are present, the interbank forward rate is a weighted average of two prices, the CIP-implied forward rate and the expected future spot rate, with weighting based on the level of conversion restrictions, 3) The offshore forward rate reflects the market's expectation of the future spot rate. Our empirical results are consistent with the model's predictions.

The rest of this paper is organized as follows. Section 2 sets up the model and discusses its theoretical and empirical implications. Section 3 presents the data description and section 4 the empirical results. Finally, section 5 concludes and proposes a potential means of reducing CIP deviation in the onshore market while maintaining conversion restrictions in the spot market. For detailed background information on the relevant markets, please refer to Wang (2010); this paper will not repeat what is covered there.

# 2 The model

## 2.1 Basic setup

There are two countries and their currencies: U.S. dollar and Chinese yuan (RMB).

There are three types of foreign exchange markets: interbank spot market, interbank (wholesale) forward market and retail forward market.[3]

There are two other interbank markets that the model treats as exogenous: the dollar money market and the yuan money market. In other words, the model takes interest rates on the dollar and RMB ( $i_{\$,t}$ and $i_{RMB,t}$ respectively) as exogenously given.

[3] The retail spot market operates under a very different set of regulations. More importantly, it is not important in determining forward prices (interbank or retail). Hence, it is excluded from the model to prevent unnecessary complications.

The spot market functions as the following. Each period, the central bank announces an exogenously given spot price ($S_t$). Anyone who wants to engage in a spot transaction has to trade with the central bank. The central bank is responsible for maintaining $S_t$ at the announced level and can achieve this via a combination of two means. The first is to fill orders at the announced price, even if this implies that the central bank will end up being a net buyer (or seller) of dollars due to imbalances between selling and buying orders. The second is to deny some transactions, leaving those who placed those denied orders unable to complete their transactions. The central bank does not deny transaction requests indiscriminately. Instead, there are certain types of transactions that it wants to deny and others that it wants to approve, but it has difficulties in differentiating between such transactions because it does not have perfect information.

Assume that every order received by the central bank belongs to exactly one of the following three groups: transactions originating from current account activities (*L*), transactions originating from capital account activities not allowed by the Chinese government (*I*), and transactions associated with forward covering (*C*). One example of an *L* transaction would be a dollar selling order placed by a bank on behalf of a Chinese exporter who needs to convert part or all of his dollar revenue into RMB so that he can pay down his RMB liabilities. An example of an *I* transaction is a dollar selling order placed on behalf of a speculator who wants to convert dollars into RMB to take advantage of anticipated RMB appreciation, higher RMB interest rates, or both. Finally, *C* transactions are spot transactions requested by forward traders who want to cover their forward positions.

By construction, the net supply of dollars in the spot market in period t, $H_t$, equals the difference between the quantities of dollar selling orders and dollar buying orders:

$$H_t = L_t^S + I_t^S + C_t^S - \left(L_t^B + I_t^B + C_t^B\right).$$ [4]

### 2.1.1 No conversion restriction

Let us first assume that conversion restriction is not imposed. Since the *L* transactions are assumed to result from current account activities, and China's current account activities are

[4] The superscript S or B indicates whether these transactions are dollar selling or dollar buying transactions. The subscript t indicates the time period.

predominantly trade related, we make the simplifying assumption that the amount of each type of *L* transaction is an increasing and concave function of the import and export growth rates:

$L_t^S = l\left(\frac{X_t}{X_{t-1}}\right)$, where $X_t$ is the volume of China's exports

$L_t^B = m\left(\frac{M_t}{M_{t-1}}\right)$, where $M_t$ is the volume of China's import

Given that *I* transactions are associated with speculative capital flows aimed at taking advantage of anticipated RMB appreciation and/or interest-rate differentials between China and U.S., the quantity of *I* transactions depends on $S_t$, $E_t[S_{t+1}]$, $i_{RMB,t}$, and $i_{\$,t}$, where $E_t[S_{t+1}]$ is the market's rational expectation of the announced spot price in the next period. In particular, assume that $I_t^S = \begin{cases} f\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}\right), if\ \frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > 1 \\ 0, o.w. \end{cases}$

and $I_t^B = \begin{cases} g\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}\right), if\ \frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}} > 1 \\ 0, o.w. \end{cases}$, where $F_{CIP,t} \equiv S_t \frac{1+i_{RMB,t}}{1+i_{\$,t}}$.

For now, we assume that functions *f* and *g* are increasing functions, but do not impose additional structures on them. The magnitude and direction of *I* transactions are assumed to depend on the ratio between $E_t[S_{t+1}]$ and $F_{CIP,t}$. This is equivalent to assuming that the magnitude and direction of *I* transactions depend on deviations from uncovered interest parity (UIP).[5] This assumption is based on empirical findings. In particular, Cheung & Qian (2010), presented empirical evidence that offshore CIP deviation is a significant determinant of net capital flows into or out of China. The spot transactions associated with these capital flights are equivalent to *I* transactions in our model. Although the equivalence between UIP deviation and offshore CIP deviation is not obvious at this point, it will be established in the next subsection (see proof of Proposition 3). Hence, the assumption that the quantity of *I* transactions depends on UIP deviations is consistent with the empirical findings presented in Cheung & Qian (2010).

### 2.1.2 Introducing conversion restriction

The central bank does not want to disturb *L* transactions but wants to block *I* transactions. Given the assumption that $I_t^S$ and $I_t^B$ cannot both be strictly positive simultaneously, the central bank only needs to apply conversion restriction on one direction in any particular period. Hence, the central bank applies conversion restriction on the dollar selling (buying) orders if and only if $\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > (<) 1$.

Each period, the central bank first attempts to identify the transactions that it considers to be *I* transactions, and then decide what fraction $\alpha_t \in [0,1]$ of this group it should deny. Unfortunately, the central bank cannot perfectly differentiate among the three types of transactions. In particular, for transaction requests of the same direction, it cannot differentiate between an *I* transaction and a *C* transaction at all.[6] More concretely, if we denote as $\hat{T}$ the central bank's classification of a particular transaction and let $T$ be its true classification, then $p\left(\hat{T} = I \middle| T = I\right) = p\left(T = I \middle| T = C\right) = 1$ and $p\left(\hat{T} = C \middle| T\right) = 0$. The central bank is better at identifying the *L* transactions from the *I* transactions, but does make mistakes. In particular, assume that $p\left(\hat{T} = I \middle| T = L\right) = \frac{(\alpha_t)^{n-1}}{n}$, where *n* is an exogenous precision parameter equal to or greater than two.

It might appear counterintuitive to assume that the central bank's mistake function for identifying *L* transactions depends on $\alpha_t$. However, when the central bank decides to tighten the convertibility restriction in the spot market, it does it via a combination of two channels. One is by increasing the list of potential suspects, and the other is by increasing the fraction of denials ($\alpha_t$). Consequently, a tightening of the conversion restriction by the central bank is reflected in both an increase in $\alpha_t$ and an increase in $p\left(\hat{T} = I \middle| T = L\right)$. Hence,

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[5] Recall that UIP deviation is defined as the discrepancy between expectation of future spot rate ($E_t[S_{t+1}]$) and $S_t \frac{1+i_{RMB,t}}{1+i_{\$,t}}$.

[6] This assumption derives from the fact that current SAFE guidelines do not even acknowledge the existence of *C* transactions, let alone their cover their determination and treatment. This lack of acknowledgment of *C* transactions is troubling. One would guess that SAFE knows that *C* transactions exist and probably wants to approve them if they can be correctly identified. Hence, a possible reason for this lack of acknowledgment (purely a conjecture at this point) is that SAFE has no way of differentiating *C* from *I* transactions.

it is conceivable that $p\left(\hat{T}=I \middle| T=L\right)$ is an increasing and convex function of $\alpha_t$. The assumption that this particular function takes the form $\frac{(\alpha_t)^{n-1}}{n}$ is a simplifying assumption that makes the algebraic manipulations more tractable later in the paper. All the theoretical results will hold if $\frac{(\alpha_t)^{n-1}}{n}$ is replaced with any other increasing and convex function of $\alpha_t$.

### 2.1.3 Impact of conversion restriction on transaction volumes

With the presence of conversion restrictions, it is natural to ask how they might influence the requested volumes of different transaction types. For instance, a tighter conversion restriction might discourage speculators from requesting spot transactions and hence decrease the amount of *I* transactions. Taking the extreme case of $\alpha_t = 1$, speculators would stop placing *I* requests because they have no chance of being approved. To incorporate this possibility, we further assume that *I* transactions, in addition to being functions of UIP deviations, are also decreasing functions of $\alpha_t$. Consequently,

$$I_t^S = \begin{cases} f\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}, \alpha_t\right), if \ \frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > 1 \\ 0, o.w. \end{cases} \quad \text{and} \quad I_t^B = \begin{cases} g\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}, \alpha_t\right), if \ \frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}} > 1 \\ 0, o.w. \end{cases}, \quad \text{where}$$

$f_2, g_2 \le 0$, $f_{22}, g_{22} \ge 0$ and $f_{12}, g_{12} \le 0$.[7] The assumption $f_{22}, g_{22} \ge 0$ reflects the belief that the influence of conversion restriction on illegitimate transactions becomes more pronounced as its level increases. The assumption that the cross derivatives are negative reflects the notion that as the conversion restriction becomes tighter, the influence of UIP deviations on the amount of *I* transactions decreases.

With regard to the impact of conversion restrictions on *L* transactions, the model assumes that the amount of *L* transactions is independent of $\alpha_t$. This assumption might not seem defendable at first glance: if a Chinese exporter cannot convert his dollar revenue into RMB, he might reduce his exporting activity or stop exporting altogether. Yet, his reaction probably depends on the denial probability for *L* transactions. For example, if the denial probability of *L* transactions fluctuates below a certain threshold, he might conduct his business without paying much attention to changes in that probability. If the denial probability for *L* transactions increases beyond a certain level, then his reaction will become more sensitive to changes in the probability.[8]

So the question boils down to how high is the denial probability on *L* transactions. When $\alpha_t = 1$ in the model, the central bank still approves the fraction $\frac{n-1}{n}$ of *L* transactions. As long as *n* is sufficiently large, the probability of denial for *L* transactions might not be high enough to cause significant changes on the amount of *L* requests.[9] Hence, *L* transactions are probably insensitive to $\alpha_t$ in China's case. Given that China has full current account convertibility according the IMF, the denial probability of *L* transactions must be low for all levels of $\alpha_t$ (i.e., sufficiently large *n*). Consequently, the model entails the simplifying assumption that trade activities, and hence the amount of *L* transactions, are independent of $\alpha_t$.

Finally, the model also assumes that the amount of *C* transactions is independent of $\alpha_t$. The amount and direction of *C* transactions depend on the amount of forward contracts, and the amount of forward contracts in the interbank market is primarily driven by the amount of each bank's exposure in the retail forward market, which is in turn driven by the underlying import and export volumes. Given that we assume that trade volumes are independent of $\alpha_t$, *C* transactions are independent of $\alpha_t$.

Consequently, the net amount of dollars supplied in the spot market for each period is described by

[7] The subscript reflects the variable with respect to which the partial derivative is taken.
[8] This line of reasoning derives from the following introspection. Every time I decide to drive, I face a strictly positive probability of being involved in a car accident, and this probability definitely fluctuates frequently according to time of day, route of planned travel, and many other factors. However, as long as this probability is below a certain tolerable threshold, I make my driving decisions independent of this probability. However, if this probability rises above the threshold, my driving activity will become more sensitive to changes in the probability. Exporters and importers facing conversion uncertainties are assumed to behave similarly.
[9] Although the model treats the precision parameter *n* as exogenously given, it is more likely that *n* is kept high enough by conscious central bank effort so that RMB remains current-account convertible. The model abstracts from the determination process of *n,* which might be fixed in the short run due to limits in technology associated with transaction differentiation, and only focuses on how the level of conversion restriction should be determined when *n* is high enough but fixed.

$$H_t = \begin{cases} \left(1-\frac{(\alpha_t)^n}{n}\right) - m\left(\frac{M_t}{M_{t-1}}\right) + (1-\alpha_t)\left[ f\left(\frac{F_{CIP,t}}{E_t[S_{t+1}]}, \alpha_t\right) + C_t^S\right] - C_t^B, if\ \frac{F_{CIP,t}}{E_t[S_{t+1}]} > 1 \\ l\left(\frac{X_t}{X_{t-1}}\right) - \left(1-\frac{(\alpha_t)^n}{n}\right) m\left(\frac{M_t}{M_{t-1}}\right) - (1-\alpha_t)\left[ g\left(\frac{E_t[S_{t+1}]}{F_{CIP,t}}, \alpha_t\right) + C_t^B\right] + C_t^S, o.w. \end{cases}$$

To summarize, $\alpha_t$ measures the level of convertibility restriction the central bank places on the spot market in period t. Essentially, a convertibility restriction of $\alpha_t$ reduces *I* transactions in two ways: It decreases the total amount of initial requests of *I* transactions and it also denies $\alpha_t$ fraction of the amount requested. Yet, it also denies the fraction $\alpha_t$ of *C* transactions and $\frac{(\alpha_t)^n}{n}$ of *L* transactions in the same direction. Consequently, imposing conversion restriction has the benefit of curbing and discouraging *I* transactions, but it also entails the costs of incorrectly denying *L* and *C* transactions. Naturally, the determination of an optimal level of conversion restriction should originate from an objective function that balances the benefits and costs. Determination of the optimal conversion restriction level will be discussed in section 2.3. The next subsection (2.2) addresses the impact of a given level of $\alpha_t$ on forward rates.

## 2.2 Forward pricing under conversion restriction

In the forward markets, both retail and interbank, counterparties in period t agree on the exchange rate for period t+1.

In the retail market, retail banks the retail forward price $(F_{ND,t})$. Taking $F_{ND,t}$ as given, retail customers enter into forward contracts with retail banks based on their hedging needs, and retail banks realize whether they are net buyers or sellers of dollars in the retail forward market. Each retail bank decides whether to cover its net position, and if so whether to cover via the interbank market or internally. For example, if a retail bank has established a net forward position to deliver yuan and receive dollars next period, it can cover the position by entering into a forward contract to deliver dollars and receive yuan in the interbank forward market. Alternatively, it can cover internally by borrowing dollars, buying RMB in the spot market, and lending the RMB proceeds. In addition, there are 16 retail banks, and additional entries by other banks are not allowed.

The retail banks are risk neutral. Consequently, the objective of a retail bank is to announce a forward rate that maximizes its expected profit, given the spot exchange rate $(S_t)$, the interbank interest rates for the two currencies $(i_{RMB,t}, i_{\$,t})$, the convertibility constraint ($\alpha_t$), and the current expectation of the future spot rate conditional on all currently available information $(E_t[S_{t+1}])$.

The retail customers do not have access to the interbank money markets of either currency nor to the interbank forward foreign exchange markets. The only way they can remove any future exchange rate volatility is via the retail forward market. They are risk averse and hence are willing to pay a certain premium to remove any exchange rate risk.

Whether a retail bank ends up being a net dollar buyer or seller in the retail forward market depends on the net hedging needs of its customers, over which the retail bank has no influence. In particular, the retail bank does not know its customers' hedging needs until after it announces $F_{ND,t}$. Of course, this need not mean that the retail bank has no control over whether it ends up as a net seller or buyer, especially if the customers are allowed to enter into forward contracts with different banks at little or no cost. For instance, if a customer has a certain positive amount of dollar revenue three months into the future and wants to lock in the exchange rate today, he will be a dollar seller in the retail forward market. The retail bank cannot change this customer's need no matter what $F_{ND,t}$ it announces. However, by announcing a low $F_{ND,t}$, it can force the customer to use a different bank because he would want to sell his dollars at the highest possible price. Likewise, any customer wanting to buy dollars forward would revert to this particular retail bank, because of the low announced price. Consequently, in this example, the retail bank increases its probability of being a net dollar seller by announcing a low price.

The above reasoning hinges on the assumption that customers can switch banks at no cost, which in practice is not true. In fact, entering a forward contract with a different bank can be quite costly for a retail customer. For a retail customer to participate in the retail forward market, he must hold an account at some retail bank. Furthermore, collateral will be required. Thus, if a person wants to enter into a forward contract with a bank of which he is not a customer, he confronts at least the costs associated with becoming a customer and transferring enough collateral to his new bank. If the price differences between his bank and other banks are not large enough to compensate for this cost, he will have no incentive to switch banks.[10]

Combining the assumption that retail banks cannot influence customers' hedging needs with the assumption that customers face strictly positive bank-switching costs implies the existence of a band of forward prices for which retail banks are completely agnostic, when announcing $F_{ND,t}$, as to whether they will become net buyers or sellers in the retail market. The width of the band depends on the customers' switching costs. For simplicity, the model assumes that the band is always wider than the distance between $E_t[S_{t+1}]$ and $F_{CIP,t}$. In facing a retail forward price of $E_t[S_{t+1}]$, the retail customer faces an expected loss of zero. His switching cost is high enough to prevent him from switching banks if the other retail banks announce $F_{CIP,t}$ as the retail forward price.

In the interbank forward market, participants also try to maximize expected profits. Forward contracts can be traded between any pair of participants, and all participants have access to the spot market and the two money markets. Participants in the interbank forward market, including the retail banks, are risk neutral. In particular, a trade can occur at forward prices ($F_{D,t}$) only if the expected profits of both counterparties are weakly greater than zero.

The convertibility restriction imposed by the central bank impacts the forward markets because transactions associated with internal covering of a forward appear to the central bank as $L$ transactions and hence face probability $\alpha_t$ of being denied. Consequently, conversion restriction translates into an uncertainty associated with the hedging of forward positions. In addition, if a trader cannot hedge part of his forward position in period t because of the convertibility constraint, he will need to use the spot market in period t+1 to obtain the necessary currency (dollars or RMB) to fulfill his forward contract, with an expected exchange rate of $E_t[S_{t+1}]$. The model also assumes that the spot transaction in pe-

[10] Even when price differences are large enough to overcome the switching cost, the customer might still be reluctant to switch banks because his objective in participating in the retail forward market might not be expected profit maximization. After all, the purpose of the retail forward market for most customers is the removal of exchange risk. Thus, so as long as the expected loss of entering into a forward contract is smaller than some constant, whose magnitude depends on the level of risk averseness, customers might not bother switching banks even if it might save them some money.

riod t+1 relating to fulfillment of the forward obligation would not encounter a convertibility constraint.[11] ′

***Proposition 1:*** Interbank forward pricing is described by

$$F_{D,t} = (1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$$

*Proof:* See Appendix.

Proposition 1 says that when a forward position cannot be fully covered internally, due to conversion restrictions, the forward price will deviate from the CIP-implied forward rate ($F_{CIP,t}$) and shift towards the expectation of future spot price ($E_t[S_{t+1}]$). If a forward can be fully covered internally, the forward price will equal $F_{CIP,t}$, which is very straightforward because convertibility restriction is the only friction considered in the model. On the other hand, if a forward cannot be covered internally at all, the forward price is determined solely by expectations of the future spot price. Finally, when there is uncertainty as to whether a forward can be covered internally, its pricing will depend on the weighted average of $F_{CIP,t}$ and $E_t[S_{t+1}]$.

Now that we have resolved the question of how interbank forwards are priced, we turn next to the search for an observable metric for $E_t[S_{t+1}]$ by examining the retail forward market. First, Proposition 2 below lists conditions under which a retail bank would want to cover its net forward position in the retail market via the interbank forward market.

***Proposition 2:*** A retail bank that is a net dollar buyer in the retail forward market would cover its position via the interbank forward market if and only if $F_{CIP,t} \geq E_t[S_{t+1}]$. Similarly, a retail bank that is a net dollar seller in the retail forward market would cover its position in the interbank forward market if and only if $F_{CIP,t} \leq E_t[S_{t+1}]$.

*Proof:* See Appendix.

[11] This assumption derives from the institutional detail that the forward trader can present the forward contract to the central bank at maturity, and it will serve as credible evidence that the requested spot transaction is associated with fulfilling a forward contract and hence will be approved. Note that such transactions maturing at (t+1) are inherently different from *C* transactions with contract date (t). Presenting a forward contract to the central bank in period t is not credible evidence that the requested spot transaction is a *C* transaction because the trader can enter into an opposite-direction forward contract (also in period t) immediately after his spot transaction is approved.

Now let us turn our attention to the determination $F_{ND,t}$ and its relationship to $E_t[S_{t+1}]$, which is summarized in Proposition 3.

***Proposition 3:*** $F_{ND,t} = E_t[S_{t+1}]$

*Proof:* See Appendix.

According to Proposition 3, offshore retail forward rates violate CIP as long as $F_{CIP,t} \neq E_t[S_{t+1}]$, and they are independent of $\alpha_t$. Note that the retail market makers (i.e. the retail banks) can realize strictly positive profits in equilibrium because they can take advantage of the price difference between the interbank and retail forward markets. This result comes from the assumptions that other banks cannot enter into the retail market and retail customers do not switch banks when $F_{ND,t} = E_t[S_{t+1}]$. Consequently, the retail banks are protected not only from new-entrant competition but also to an extent from competing with each other, which allows them to make strictly positive profit in equilibrium.

## 2.3 Optimal conversion restriction policy

We now shift our focus to the process of determining conversion restriction. Given that the goal of imposing conversion restriction is to block and discourage *I* transactions, the direction of conversion restriction depends on the relative magnitudes of $F_{CIP,t}$ and $E_t\left[S_{t+1}\right]$. In particular, the central bank should impose conversion restrictions on dollar selling (buying) transactions when $F_{CIP,t} > (<) E_t\left[S_{t+1}\right]$ and should not impose any restrictions when $F_{CIP,t} = E_t\left[S_{t+1}\right]$.

Given that the officially stated goal of imposing spot market conversion restrictions is to block and discourage *I* transactions without disturbing *L* transactions, the Chinese authorities *should* determine its conversion restriction by weighing the benefits and costs of conversion restrictions. Thus the central bank's objective function should be the following:

Taking $S_t$ , $E_t[S_{t+1}]$ , $i_{RMB,t}$ , and $i_{\$,t}$ as given,

$$\min_{\alpha_t \in [0,1]} \begin{cases} (1-\alpha_t)\, f\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}, \alpha_t\right) + \lambda \frac{(\alpha_t)^n}{n} l\left(\frac{X_t}{X_{t-1}}\right), if\ \frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > 1 \\ (1-\alpha_t)\, g\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}, \alpha_t\right) + \lambda \frac{(\alpha_t)^n}{n} m\left(\frac{M_t}{M_{t-1}}\right), o.w. \end{cases}$$

where $\lambda > 0$ is the cost that the central bank attaches to the mistake of incorrectly denying *L* transactions.[12] Note that the first component of the objective function represents the false negatives (mistakenly approving *I* transactions) and the second component represents false positives (mistakenly blocking *L* transactions).[13]

Taking the first order condition, the level of convertibility constraint in the spot market should be determined by the following equations:

$$f\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}, \alpha_t\right) = (1-\alpha_t)\, f_2\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}, \alpha_t\right) + \lambda (\alpha_t)^{n-1} l\left(\frac{X_t}{X_{t-1}}\right), if\ \frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > 1 \qquad \text{(a)}$$

$$g\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}, \alpha_t\right) = (1-\alpha_t)\, g_2\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}, \alpha_t\right) + (\alpha_t)^{n-1} \lambda m\left(\frac{M_t}{M_{t-1}}\right), o.w. \qquad \text{(b)}$$

***Proposition 4:*** The level of conversion restriction should increase with the absolute value of UIP deviation and decrease with international trade growth.
*Proof:* See Appendix.

## 2.4 Empirical implications

***Implication 1:*** Proposition 3 implies that $\lim_{n\to\infty} \frac{1}{n} \sum_{t=1}^{n} (F_{ND,t} - S_{t+1}) = 0$ .

***Implication 2:*** An immediate implication of Proposition (1) is that for $F_{D,t}$ to violate CIP two conditions are required: $E_t[S_{t+1}] \neq F_{CIP,t}$ and $\alpha_t > 0$ . Absent the first condition, $F_{D,t}$ has

[12] The exact and optimal magnitudes of $\lambda$ are also matters for investigation, but are beyond the scope of the current paper.
[13] Given that *C* and *I* transactions cannot be differentiated at all by the central bank, the cost of mistakenly denying *C* transactions is not incorporated into the central bank's objective function. Although CIP deviations in the interbank forward market should be considered a cost when determining the optimal level of conversion restriction, the central bank cannot incorporate a cost that it cannot identify and hence quantify.

no room to deviate from CIP; and without the second, traders will not rate $E_t[S_{t+1}]$ into their determination of $F_{D,t}$. But we see from Equation (a) that $\alpha_t$ is increasing in the absolute distance between $E_t[S_{t+1}]$ and $F_{CIP,t}$; hence an empirical implication of the model is that CIP deviations and UIP deviations should be positively correlated. Combining this with Proposition 3, by which offshore forwards are a measure of spot rate expectations, implies that the correlation between CIP deviations from offshore and onshore markets should be positive because CIP deviations in the offshore market are equivalent to UIP deviations in this model. Furthermore, CIP deviation in the offshore market is a necessary condition for onshore deviation in general, and this condition becomes a sufficient condition for the Chinese authorities to impose convertibility restrictions in the spot market.

***Implication 3:*** Combining the results of Proposition 1 and Proposition 3, the following relationship obtains: $F_{D,t} = (1-\alpha_t)F_{CIP,t} + \alpha_t F_{ND,t}$, which says that the forward price in the interbank market should be a weighted average of $F_{CIP,t}$ and the forward price in the retail market $(F_{ND,t})$. This naturally leads to

Regression (1) $\quad F_{D,t} = \delta_1 F_{CIP,t} + \delta_2 F_{ND,t} + \varepsilon_t$

Hence, conditional on the assumption that convertibility restriction does not change during a time interval, $\alpha_t$ can be estimated by $\hat{\delta}_2$ in Regression (1). Under the more realistic assumption that the level of convertibility restriction did change over the sample period, $\hat{\delta}_2$ would be an estimate of the average level of convertibility restrictions over the sample period. Hence, Regression (1) can be used to test the hypothesis initially proposed in Wang (2010), which claims that level of convertibility restriction increased after SAFE announced on May 18, 2007 to increase its monitoring effort of the spot foreign exchange market. In particular, performing Regression (1) over two sample periods, pre-and post announcement (with May 18, 2007 as the dividing), should generate $\hat{\hat{\alpha}}_{post} > \alpha_{pre}$ if the hypothesis is correct.

***Implication 4:*** In the model, the only variables that influence $\alpha_t$ are UIP deviation and export growth. Although additional structures on the functional forms of *f* and *g* need to be imposed to ensure that there is a clean linear relationship among them, Proposition 4 gives us a prior on how each should influence $\alpha_t$ directionally. Acknowledging the need for additional structure for a structural regression, perhaps Regression (2) can serve as a reduced form for empirical testing.

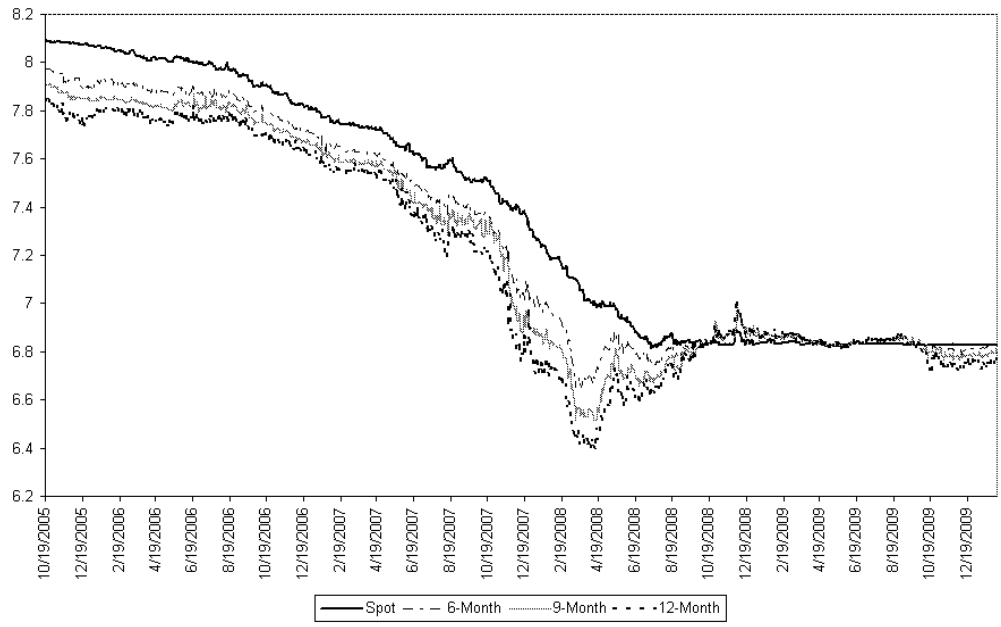
$$\text{Regression (2)} \qquad \alpha_t = \beta_0 + \beta_1 \ln\left(\frac{F_{CIP,t}}{F_{ND,t}}\right) + \beta_2 \ln\left(\frac{X_t}{X_{t-1}}\right) + \nu_t$$ [14]

In particular, Proposition 4 predicts that $\beta_1 > 0$ and $\beta_2 < 0$. Although there is no direct measure of $\alpha_t$, we have the relationship $F_{D,t} = (1-\alpha_t)F_{CIP,t} + \alpha_t F_{ND,t}$.

# 3 Data description

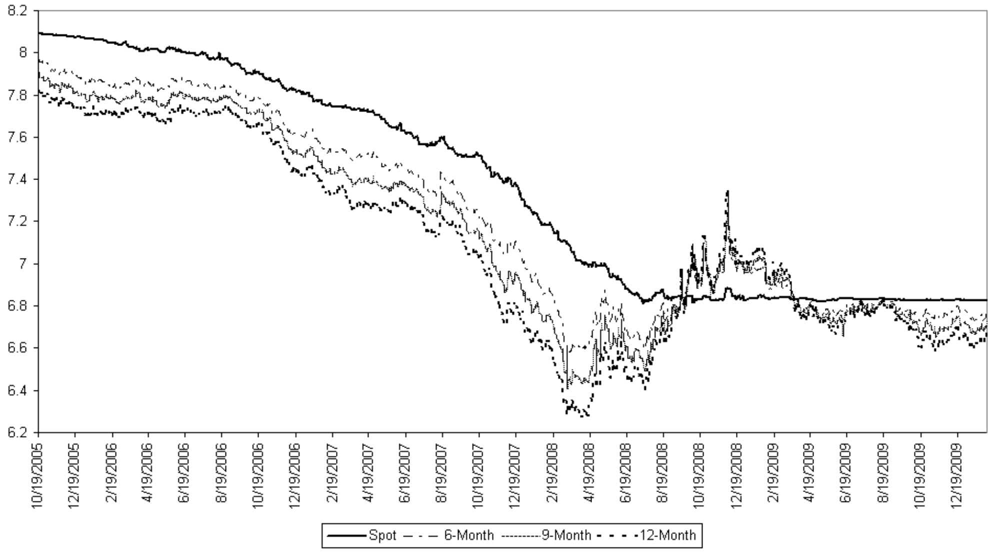
With respect to forward rates of both NDF and DF, we obtained daily observations from October 19, 2005[15] to February 5, 2010. The NDF rates are from the Hong Kong NDF market and the source of DF rates is the CFETS. Figures 2 and 3 depict the NDF and DF rates respectively, along with the daily closing spot rates announced by SAFE.

Figure 2 Historical deliverable forward rates (RMB/$)




[14] The linear set up might not be as reduced as it appears, as whatever the form of the structural relationship, a log-linear approximation might be able to generate Regression (2).
[15] The first day DF was introduced in CFETS.

Figure 3 Historical non-deliverable forward rates (RMB/$)




Figures 4 and 5 respectively illustrate historical SHIBORs and dollar Libors for various maturities. SHIBOR is obtained from NIFC and the source of dollar Libors is the British Bankers' Association. For unidentified reasons, SHIBORs prior to October 9, 2006 are beyond the scope of public access and are not included in this study.

Figure 4 Historical SHIBOR (percentage)

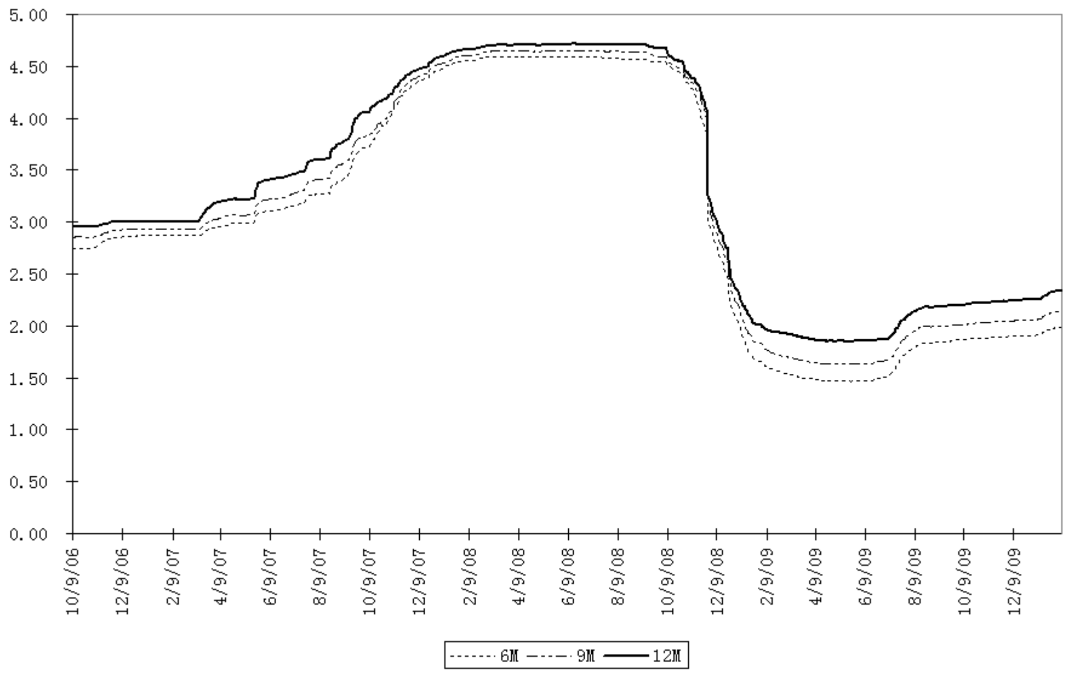
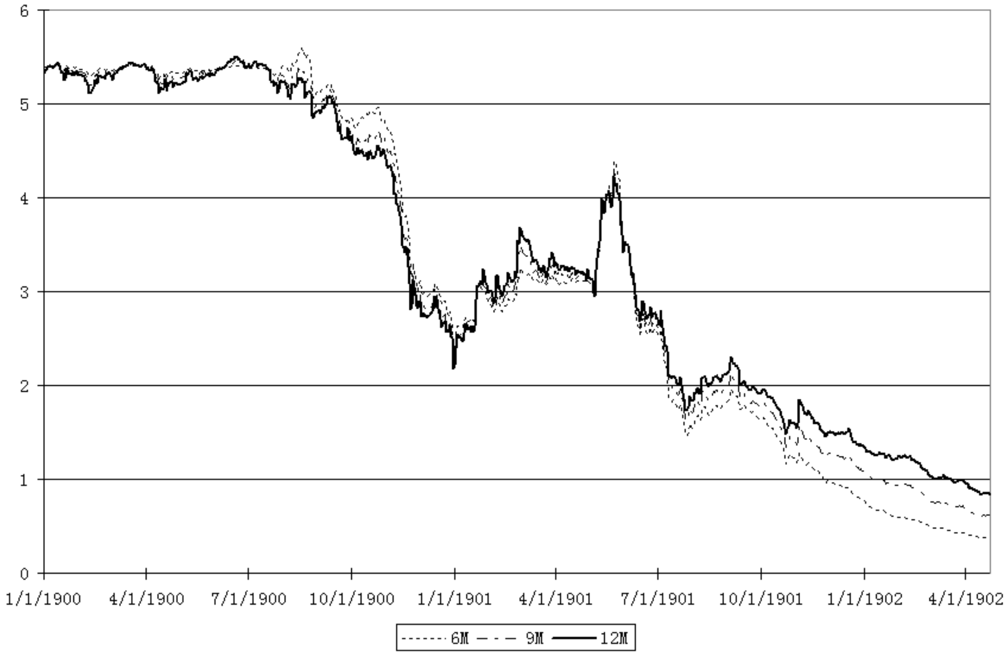
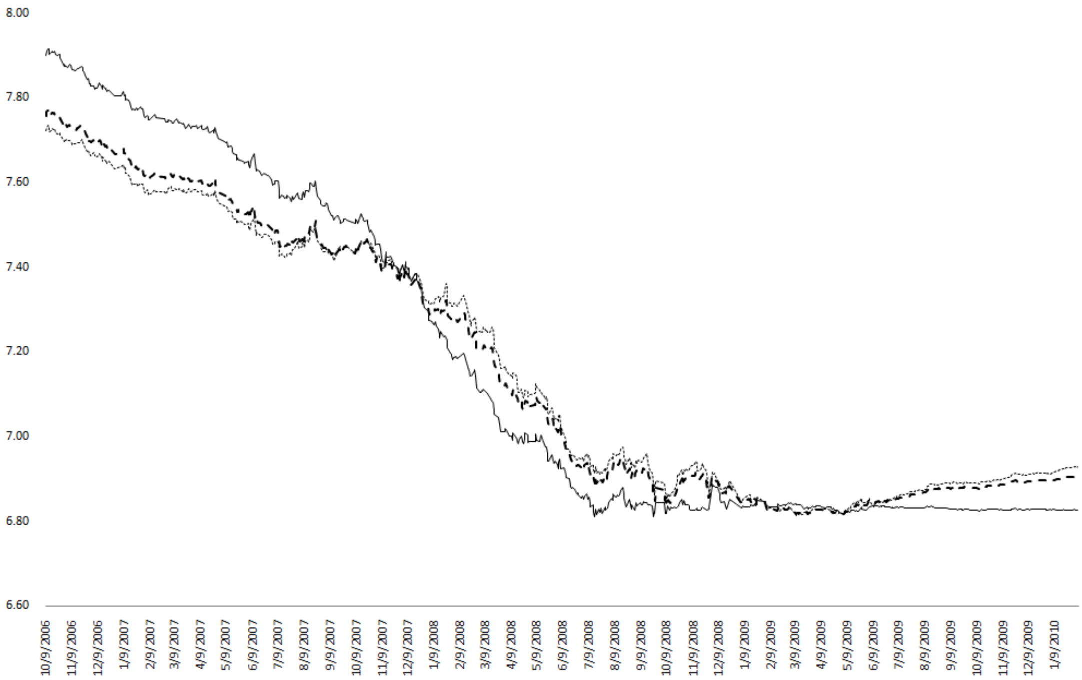


Figure 5 Historical Dollar Libor (percentage)




Using spot rates and interest rates above, one can calculate the CIP-implied forward rates for various maturities, which are presented in Figure 6.

Figure 6 CIP implied forward rates



# 4 Empirical results

***Implication 1:*** The model predicts that NDF is equal to the market's expectation of the future spot rate, so that $\lim_{n\to\infty}\frac{1}{n}\sum_{t=1}^{n}(F_{ND,t} - S_{t+1}) = 0$

Table 1 lists the sample average differences using offshore forward rates from October 19, 2005 to February 5, 2010 by forward maturities. Although the sample averages do not equal zero, none of the averages are off the mark by more than a penny.[16] Hence, the average prediction error of offshore forwards does not appear economically significant. In addition, for all maturities, zero is within 1/10 to 1/5 standard deviations of the sample averages. Given the closeness of the sample averages to zero, there is reason to believe that offshore forward prices are unbiased predictors of the future spot price, consistent with Implication 1.

Table 1 Difference between forward rate and realized spot rate

| October 19, 2005-February 5, 2010 | | | |
|---|---|---|---|
| | 6M | 9M | 12M |
| Mean | 0.0025 | 0.0040 | 0.0051 |
| Std Dev | 0.0166 | 0.0249 | 0.0334 |
| # Obs | 990 | 908 | 860 |

***Implication 2:*** UIP deviations and onshore CIP deviations should be positively correlated. In addition, given that empirical results for Implication 1 reveals that offshore forwards are measures of future spot rate expectations, then CIP deviations of onshore and offshore markets should also be positively correlated.

The fact that CIP deviations in the onshore market coincided with UIP deviations was initially documented by McKinnon et al (2010) although the authors did not use offshore forward rates as measures of market expectation of future spot rate but used instead the realized spot rates. The simultaneous violations of CIP and UIP in the dollar-RMB market are also cited in Wang (2010). However, these two papers provide no theoretical justification for the dual violations observed. The model in this paper shows that UIP violation is a necessary condition for CIP violation in the onshore market.

Figure 7 is a scatter plot of onshore CIP deviation versus offshore CIP deviation (also a measure of UIP deviation) using 12-month forward rates between October 9, 2006 and February 5, 2010. Visual inspection easily identifies the strong positive correlation between the two series.

Figure 7 12 month CIP deviations (onshore vs. offshore)

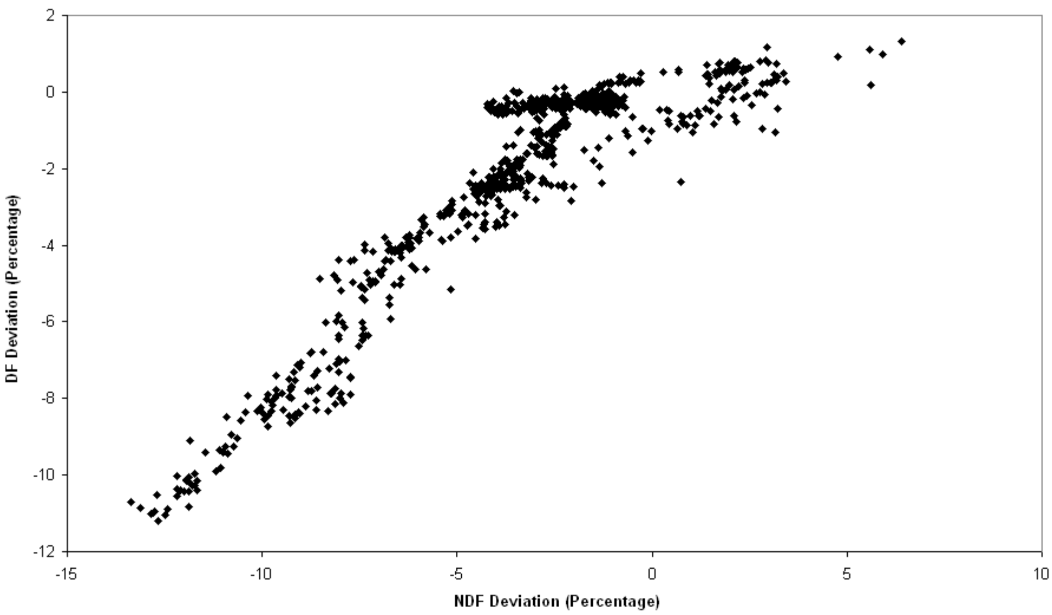



Table 2 shows the correlation between onshore CIP deviation and offshore CIP deviation for forwards of various maturities.

Table 2 Correlation between onshore and offshore CIP deviations

| October 9, 2006-February 5, 2010 | | | |
|---|---|---|---|
| | 6M | 9M | 12M |
| Correlation | 0.8959 | 0.9064 | 0.9161 |

DF and NDF CIP deviations are strongly positively correlated across maturities, which is consistent with Implication 2.

[16] Given that the averages are measured in RMB.

***Implication 3:*** $F_{D,t} = (1-\alpha_t)F_{CIP,t} + \alpha_t F_{ND,t}$

Tables 3 and 4 show the results of Regression (1). Due to the SAFE announcement on May 18th, 2007, there is reason to believe that there was an increase in $\alpha$ after that date. Consequently, the sample is divided into two periods: pre-announcement and post-announcement.

Table 3 Regression (1) Estimation Results by Forward Maturities

| October 9, 2006-May 17, 2007 | | | |
|---|---|---|---|
| | 6M | 9M | 12M |
| $\hat{\delta}_1 \approx 1-\alpha$ | 0.8938 | 0.9275 | 0.9567 |
| | (0.0167) | (0.0105) | (0.0097) |
| $\hat{\delta}_2 \approx \alpha$ | 0.1062 | 0.0718 | 0.0410 |
| | (0.0169) | (0.0107) | (0.0100) |
| Adj. $R^2$ | 0.9862 | 0.9870 | 0.9778 |
| # Obs | 137 | 137 | 137 |

Table 4 Regression (1) Estimation Results by Forward Maturities

| May 18, 2006-Feburary 5, 2010 | | | |
|---|---|---|---|
| | 6M | 9M | 12M |
| $\hat{\delta}_1 \approx 1-\alpha$ | 0.3209 | 0.2566 | 0.2562 |
| | (0.0119) | (0.0118) | (0.0102) |
| $\hat{\delta}_2 \approx \alpha$ | 0.6782 | 0.7438 | 0.7434 |
| | (0.0121) | (0.0121) | (0.0106) |
| Adj. $R^2$ | 0.9600 | 0.9262 | 0.8987 |
| # Obs | 653 | 638 | 653 |

As mentioned in the previous section, if one has the prior that $\alpha_t$ did not change within a particular time sample, then estimates of Regression (1) will give us an estimate of $\alpha_t$ during this period. However, if there are reasons to believe $\alpha_t$ did change within a time sample, then Regression (1) can only generate *average* $\alpha_t$. Prior to the SAFE announcement on May 18, 2007, one can perhaps argue that the level of conversion restriction was relatively constant because CIP deviations during this period, though present, were relatively less volatile. After the announcement, however, the notion that $\alpha_t$ increased once and remained flat at the higher level is less defendable. This is because the magnitude of UIP deviations after the announcement was also changing rapidly, which suggests that the level of conversion restrictions was probably also being adjusted during this period. Hence, although results from Table 3 can perhaps be argued to represent the level of conversion restriction that was constant prior to the SAFE announcement, results from Table 4 should be interpreted as an average of the regularly changing post-announcement conversion restrictions.

Under the relatively safer interpretation, that results from Regression (1) represent an average of conversion restriction levels within a period, the results are consistent with the hypothesis that SAFE indeed imposed tighter post-announcement conversion restrictions, which is reflected in the significant increase in $\hat{\alpha}$ after the announcement across all forward maturities examined.

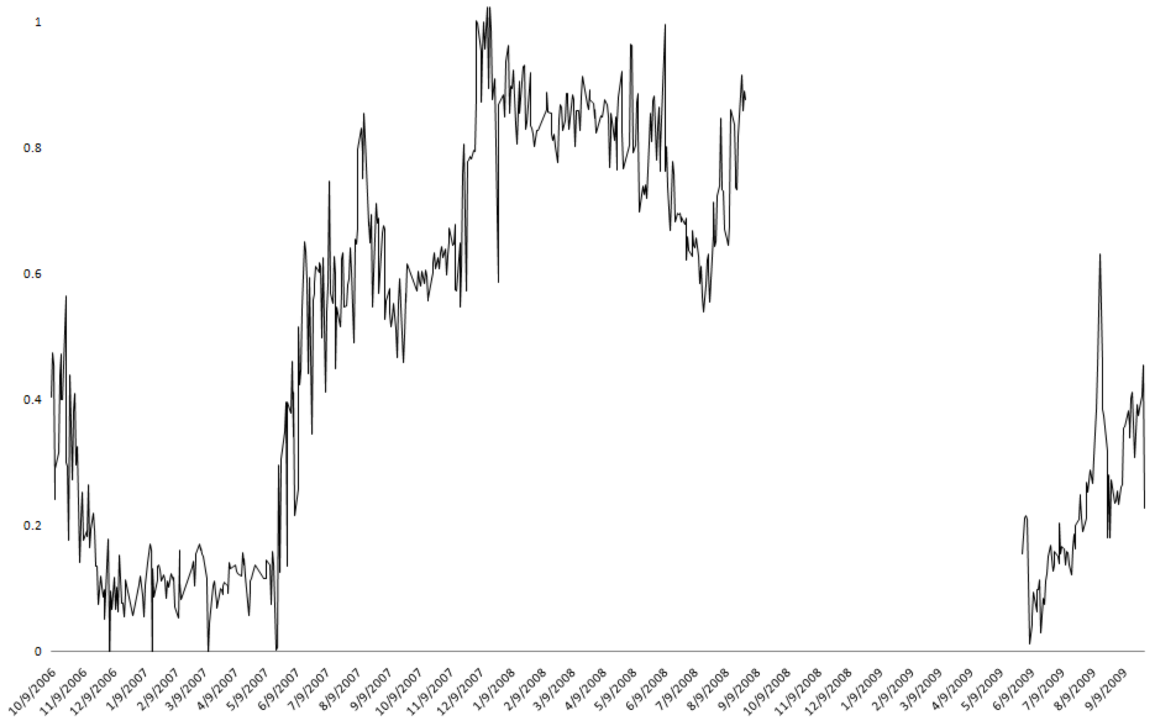
***Implication 4:*** Regression (2) $\alpha_t = \beta_0 + \beta_1 \ln\left(\frac{F_{CIP,t}}{F_{ND,t}}\right) + \beta_2 \ln\left(\frac{X_t}{X_{t-1}}\right) + \nu_t$

The error terms are assumed to have zero mean and finite variance, to be iid over time and independent of the RHS variables.

One can will believe that from May 18, 2007 onward SAFE began to actively adjust the conversion restrictions. The model predicts that $\beta_1 > 0$ and $\beta_2 < 0$. Intuitively, conversion restriction should tighten when *I* activities are rampant, but should be toned down if there are also many *L* transactions.

Using 12-month forward rates, the implied $\alpha_t$ is calculated from the relationship $F_{D,t} = (1-\alpha_t)F_{CIP,t} + \alpha_t F_{ND,t}$ (Figure 8), which makes up the LHS variable of Regression (2). Regression 2 also requires $\ln\left(\frac{F_{CIP,t}}{F_{ND,t}}\right)$ (Figure 9) and the natural log of China's export growth. Given that daily export volumes between China and U.S. are unavailable, monthly volumes are used instead. To perform Regression 2, I use the monthly growth for each day of the given month. Hence, $\ln\left(\frac{X_t}{X_{t-1}}\right)$ is a step function (Figure 10). The source is IMF Direction of Trade database.

Figure 8 Implied $\alpha_t$ using 12-month forward rates




Regression (2) is performed over three time intervals, for robustness checking:

A. May 21, 2007 to Aug 29, 2008. The starting date is the first trading day after SAFE's announcement to increase conversion restriction and the ending day is picked to avoid the effects of the recent financial crisis.[17]

B. May 21, 2007 to Aug 29, 2008 and Jun 1, 2009 to Sep 30, 2009. Once again, the gap is chosen to avoid the financial crisis effects.[18]

C. Oct 9, 2006 to Aug 29, 2008 and Jun 1, 2009 to Sep 30, 2009.

[17] The few months surrounding the financial crisis are avoided on purpose because many other factors could have contributed to disturbances in foreign exchange forward markets across the world, and this model is not designed to explain forward-market behavior during the crisis.

Figure 9 Natural log of offshore CIP deviations (12 month forwards)

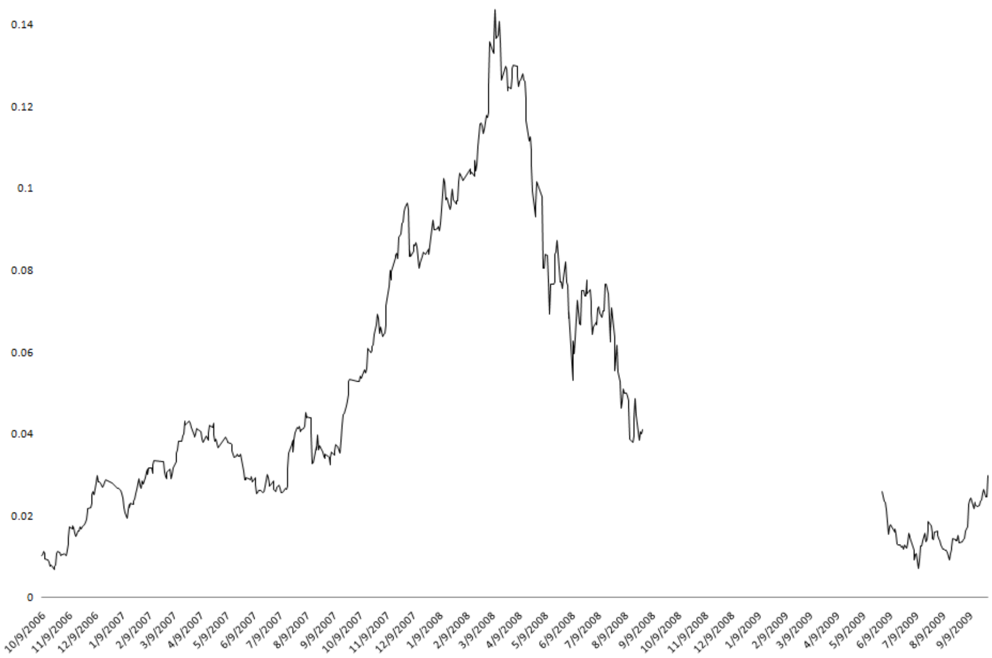
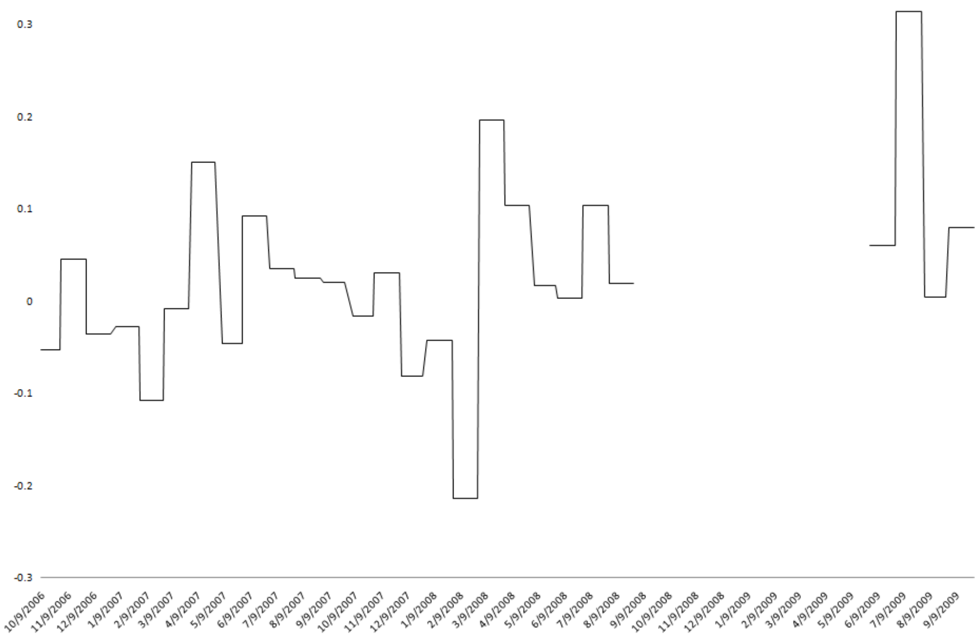



Figure 10 Natural log of China-U.S. export growth




[18] I do not know how long the impacts of the financial crisis might have lingered in China's forward market. Hence, a long gap is picked in hopes that any remaining impacts have mostly dissipated.

Results for Regression (2) are presented in Table 5.

Table 5 Regression (2) Estimation Results

| | A | B | C |
|---|---|---|---|
| $\hat{\beta}_1$ | 3.5876 | 5.1835 | 6.6373 |
| | (0.2257) | (0.2098) | (0.2435) |
| $\hat{\beta}_2$ | -0.2923 | -0.5687 | -0.1934 |
| | (0.0841) | (0.0734) | (0.0853) |
| $\hat{\beta}_0$ | 0.4610 | 0.3262 | 0.1607 |
| | (0.0173) | (0.0152) | (0.0152) |
| Adj. $R^2$ | 0.4578 | 0.6731 | 0.5897 |
| # Obs | 309 | 394 | 532 |

In all three scenarios, the estimates are statistically significant and the signs are consistent with model prediction.

# 5 Conclusion

Capital control measures in China, along with any market frictions they generate, are a part of life. This paper shows that one particular side effect of conversion restrictions in the spot foreign exchange market is the violation of CIP in the onshore forward market. In particular, Chinese authorities impose conversion restrictions in an effort to achieve capital flow balance by blocking certain capital account transactions. When deciding the level of conversion restrictions, Chinese authorities face the tradeoff between achieving capital flow balance and disturbing current account transactions. This paper proposes a theoretical framework that predicts that conversion restrictions should increase with capital account transactions and decrease with current account transactions. The conversion restriction in turn places a binding constraint on forward traders' ability to cover a forward position, thus leading to the observed CIP deviations in the onshore dollar-RMB forward market. Consequently, movements in onshore CIP deviations primarily reflect adjustments to the level of conversion restrictions by the authorities.

More particularly, the model predicts that the onshore forward rate is equal to a weighted average of CIP-implied forward rate and the market's expectation of the future spot rate, with weighting determined by the level of conversion restriction. As a secondary result, the model also implies that offshore non-deliverable forwards reflect the market's expectation of the future spot rate. Using daily data for October 9, 2006 to February 5, 2010, the empirical results confirm that movements of CIP-implied forward rate and off-shore forward rate can explain nearly all of the movement of onshore forward rate. Using daily data from October 19, 2005 and February 5, 2010, the prediction error for future spot rate using the offshore forward rate is not economically significant. Finally, empirical evidence suggests that conversion restriction in China indeed increases with UIP deviation and decreases with export growth.

In light of the theoretical and empirical results presented in this paper, a potential solution to decrease CIP deviation in the onshore forward market while maintaining a strictly positive level of conversion restriction on the spot market is to have market participants credibly and truthfully signal that certain spot transactions are related to forward hedging and have SAFE approve these transactions upon observing the signal, which would make for a very interesting mechanism-design problem. Until such a signal is discovered, however, we will continue to see CIP-deviations in the onshore forward market.

# Appendix

### Proof of proposition 1

For the party that buys dollars forward (dollar forward buyer), he will gain $F_{CIP,t} - F_{D,t}$ in period t+1 if his covering transaction is approved. If not, his expected payoff in period t+1 is $E_t[S_{t+1}] - F_{D,t}$. Given that he wants to maximize the expected payoff, he would like to have $F_{D,t}$ as low as possible. In addition, because he is assumed to be risk neutral, he will enter into such a contract if and only if

$(1-\alpha_t)(F_{CIP,t} - F_{D,t}) + \alpha_t(E_t[S_{t+1}] - F_{D,t}) \geq 0$, or equivalently

(1.1) $$F_{D,t} \leq (1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$$

Similarly, the dollar seller in this transaction will enter into such a contract if and only if $(1-\alpha_t)(F_{D,t} - F_{CIP,t}) + \alpha_t(F_{D,t} - E_t[S_{t+1}]) \geq 0$, or equivalently

(1.2) $$F_{D,t} \geq (1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$$

Combining (1.1) and (1.2) yields $F_{D,t} = (1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$.

QED.

### Proof of proposition 2

If a retail bank that has accumulated a net dollar-buying position in the retail forward market and decides to cover via the interbank forward market, it faces a payoff of $F_{D,t} - F_{ND,t}$. By Proposition 1, this payoff is equal to $(1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}] - F_{ND,t}$ [19]. If it does not cover its retail position, then its expected payoff is $E_t[S_{t+1}] - F_{ND,t}$. Since the retail bank is risk neutral, it cares only about the expected payoff when deciding whether to cover. Consequently, it covers its retail position if and only if

$$(1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}] - F_{ND,t} \geq E_t[S_{t+1}] - F_{ND,t}$$
$$\Leftrightarrow (1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}] \geq E_t[S_{t+1}]$$
$$\Leftrightarrow (1-\alpha_t)F_{CIP,t} \geq (1-\alpha_t)E_t[S_{t+1}]$$
$$\Leftrightarrow F_{CIP,t} \geq E_t[S_{t+1}]$$

The second part of Proposition 2, regarding the net dollar seller in the retail forward market, can be proved by symmetry.

QED

Proof of proposition 3

When a retail bank announces $F_{ND,t}$, it takes $F_{CIP,t}$ and $E_t[S_{t+1}]$ as given. Thus there are three scenarios to analyze, $F_{CIP,t} < E_t[S_{t+1}]$, $F_{CIP,t} > E_t[S_{t+1}]$, and $F_{CIP,t} = E_t[S_{t+1}]$.

Assume that $F_{CIP,t} < E_t[S_{t+1}]$. Then by Proposition 2, a retail bank with a net position to sell dollars in the retail market would cover its position while a retail bank with a net position to buy dollars in the retail market would not cover its position. From earlier discussion, there is a range of prices around $E_t[S_{t+1}]$ such that if all retail banks stay within this range, they will not know the probability distribution of their becoming net buyers or net sellers of dollars in the retail forward market, which means that they do not know the unconditional expected payoff when they announce $F_{ND,t}$. Consequently, they will focus on the expected payoff conditional on their net positions when determining $F_{ND,t}$.

Under the current scenario, conditional on being a net seller of dollar in the retail market, a retail bank's payoff is $F_{ND,t} - (1-\alpha_t)F_{CIP,t} - \alpha_t E_t[S_{t+1}]$ because it will cover its position. Conditional on being a net buyer of dollar in the retail market, the retail banks expected payoff is $E_t[S_{t+1}] - F_{ND,t}$ because it will not cover its position. The retail bank is willing to trade at $F_{ND,t}$ as long as the conditional expected payoffs are greater than or equal to zero.

Conditional on being a net buyer of dollar in the retail market, the retail bank will announce $F_{ND,t}$ such that $E_t[S_{t+1}] - F_{ND,t} \geq 0$. Conditional on being a net seller of dollars in the retail market, the retail bank's objective is to maximize $F_{ND,t} - (1-\alpha_t)F_{CIP,t} - \alpha_t E_t[S_{t+1}]$. Hence, the retail bank's optimization problem prior to finding out whether it is a net buyer or net seller of dollars in the retail market can be summarized as to maximize $F_{ND,t} - (1-\alpha_t)F_{CIP,t} - \alpha_t E_t[S_{t+1}]$ with respect to $F_{ND,t}$ such that $E_t[S_{t+1}] - F_{ND,t} \geq 0$. The solution to this maximization problem is $F_{ND,t} = E_t[S_{t+1}]$. Note that by announcing $F_{ND,t} = E_t[S_{t+1}]$, the retail bank's expected gain is (weakly) positive regardless of whether it ends up being a net seller or buyer.

Now we have to consider whether any retail bank would have an incentive to announce a price outside of the agnostic range if all other retail banks remain within the

[19] Even if the retail bank decides to cover its position internally it would receive this payoff.

range. If a retail bank announces a price higher than the range, then it will become a net buyer of dollars. By Proposition 2, it would not cover its position, resulting in a negative expected gain at maturity, which is strictly less than its expected gain by announcing $E_t[S_{t+1}]$. Similarly, if it announces a price below the range, it would become a net seller of dollar, $F_{ND,t} - (1-\alpha_t)F_{CIP,t} - \alpha_t E_t[S_{t+1}] < F_{ND,t} - F_{CIP,t} < 0$, which is again strictly less than the expected payoff associated with announcing $E_t[S_{t+1}]$.

The case of $F_{CIP,t} > E_t[S_{t+1}]$ can be analyzed in a similar fashion, with a few minor changes and hence is skipped.

Finally, when $F_{CIP,t} = E_t[S_{t+1}]$, a retail bank with a net position in the retail market will cover regardless of the direction of its net position. Conditional on being a net buyer of dollars in the retail market, a retail bank is willing to trade if and only if $(1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}] - F_{ND,t} \geq 0$. Similarly, conditional on being a net seller of dollars in the retail market, a retail bank is willing to trade if and only if $F_{ND,t} - (1-\alpha_t)F_{CIP,t} - \alpha_t E_t[S_{t+1}] \geq 0$. The only value of $F_{ND,t}$ that concurrently satisfies both inequalities is $F_{ND,t} = E_t[S_{t+1}]$. Deviating by announcing a price outside of the agnostic range would again ensure negative expected payoffs.

QED

## Proof of proposition 4

Start with Equation (a) and assume that $\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}$ has increased. This leads to an increase in the LHS and a decrease in the RHS because $f_1 > 0$ and $f_{12} \leq 0$. Consequently, $\alpha_t$ needs to change in direction so as to bring the expression back to equality. The direction is up. To see this, note that an increase in $\alpha_t$ would reduce the LHS because $f_2 \leq 0$. The fact that an increase in $\alpha_t$ would increase the RHS is less obvious from inspection but becomes clear by looking at the partial derivative of the RHS with respect to $\alpha_t$, explicitly

(c) $$(1-\alpha_t)\, f_{22}\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]},\alpha_t\right) - f_2\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]},\alpha_t\right) + \lambda(n-1)(\alpha_t)^{n-2}\, l\left(\frac{X_t}{X_{t-1}}\right)$$

Note that the first term of (c) is nonnegative because $f_{22} \geq 0$, the second term is a subtraction of a negative number, and the third term is positive. Consequently, (c) as a whole is positive, implying that the RHS of (a) is increasing in $\alpha_t$.

Now we shift our attention to the trade volume. When export growth ($\frac{X_t}{X_{t-1}}$) increases, expression (a) again becomes an inequality. To restore equality, $\alpha_t$ has to change so as to increase the LHS and decrease the RHS of (a), i.e. $\alpha_t$ must decrease.

The argument using (b) is almost identical and is hence skipped.

QED

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