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Convertibility Restriction Determination in China's Foreign Exchange Market and its Impact on Forward Pricing

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Abstract

Different from the well established markets such as the dollar-Euro market, recent CIP deviations observed in the onshore dollar-RMB forward market were caused by conversion restrictions in the spot market rather than changes in credit risk and/or liquidity constraint. This paper proposes a theoretical framework under which the Chinese authorities impose conversion restrictions in the spot market in an attempt to achieve capital flow balance, but faces the tradeoff between achieving such balance and disturbing current account transactions when determining the level of conversion restriction. 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 onshore forward rate is equal to a weighted average of CIP-implied forward rate and the market's expectation of future spot rate, with the weight determined by the level of conversion restriction. As a secondary result, the model also implies that offshore non-deliverable forwards reflect to the market's expectation of future spot rate. Empirical results are consistent with these predictions.

Key words: China, foreign exchange, covered interest rate parity, deliverable forward, non-deliverable forwards

JEL codes: F31, F42

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1. Introduction

China's young onshore interbank foreign exchange forward market has received surprisingly little academic attention since its establishment in October 2005. Although transaction volume data of this wholesale market has 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 retail forward market between the RMB and U.S. dollar had a typical daily volume of about \$150 to 200 million while exhibiting an upward trend toward \$600 million (Fung et al. 2004); consequently, one has reason to expect that the daily trading volume on the onshore wholesale market be even greater than \$600 million. In fact, anecdotal evidence suggests that the daily trading volume of the onshore forward market could be well over \$1 billion.

It has been recently documented that forward prices in this interbank market exhibit persistent violations of covered interest rate parity (CIP) (Wang 2010 and McKinnon et al. 2010). Covered interest rate parity states that the forward price between two currencies should equal to the spot rate times the interest rate differential of 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 1 unit of currency B). As the CIP formula suggests, a trader can in theory realize arbitrage profit by borrowing in one currency, convert the borrowing proceeds into the other currency in the spot market, lend in the other currency, and convert back to the original currency using a forward contract if forward rate deviates from CIP. Figure 1 shows the deviations forward rates from CIP-implied forward rate of

12-month forwards (both onshore deliverable forwards and off-shore non-deliverable forwards) using 12-month Libor and 12-month Shibor.

<Insert Figure 1 here>

As Figure 1 reflects, besides CIP violations of both onshore and offshore forward prices, there also appears to be significant price differences between the onshore-interbank-deliverable forwards (DF) and the offshore-retail-non-deliverable forwards (NDF). Both the violation of CIP in the interbank market and the price discrepancy between onshore and offshore forwards appear to generate potential arbitrage opportunities to market participants.² Given the amount of money at stake, any potential arbitrage opportunities in China's foreign exchange forward markets deserve careful investigation by both academic researchers and market participants.

Other scholars have studied the empirical robustness of CIP in the past. Only focusing on the past decade, violations of CIP have been used to determine the degree financial integration of the EU (Holmes 2000). Until very recently, data involving forward market between currencies of developed countries reflect the empirical robustness of CIP. High frequency data reflects 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.

² For the most part in China's case, the deviations reflect arbitraging opportunity involving borrowing in dollar, shorting dollar in the spot market, lending in RMB, and long dollar in the forward market. There appears to be a short exception from October 2008 to April 2009, during which the deviations were not only modest in magnitude but also reflected arbitrage opportunities in the opposite direction.

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 deviation following the Lehman Brother bankruptcy in September 2008 in the Dollar-Euro forward market using Dollar Libor and Euro Libor, but did not provide a detailed explanation for the cause of such deviation. Baba & Packer also identified CIP violations between dollar and Euro over similar time period using 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 identified for CIP violation in the dollar-Euro market cannot satisfactorily explain the CIP deviations we have witnessed in dollar-RMB market. Three inconsistencies between the dollar-Euro market and the dollar-RMB market discredit the notion that the 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 dollar-EURO market were at its peak around October 2008, which

was shortly after the Lehman bankruptcy, CIP violations in dollar-RMB market have already mitigated.

- (ii) **Magnitudes:** The magnitudes of CIP deviation 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 Figure 1.
- (iii) **Direction:** In developed markets, scholars have primarily focused their attention on CIP deviations in the months following the Lehman bankruptcy, which was a reasonable decision because the deviations were greatest in magnitude over this period. In particular, the CIP deviation in these markets represents arbitrage opportunities involving shorting dollar in the spot market (Coffey et al. 2009). CIP deviations in the Chinese market also reflect arbitrage opportunity in the same direction for the most part during my sample period. However, during the months following Lehman's bankruptcy, CIP deviations in the dollar-RMB market were not only moderate in magnitude, but also reflected arbitraging opportunities involving longing dollar in the spot market, which are 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 for CIP deviations in the two markets are different and any reasons identified

to explain CIP deviations in dollar-Euro market probably are not convincing causes for the CIP deviations in the dollar-RMB market for the most part.

For the offshore dollar-RMB NDF market, I am not the first to document CIP violations either. In fact, CIP deviations in the offshore NDF market have been documented as early as 2004 (Ma et. al 2004). CIP violations in the offshore dollar-RMB have also been used as evidence supporting the efficacy of Chinese capital control policies (Ma & McCauley 2008). In particular, Ma & McCauley argue that the reason for persistent CIP deviations in the offshore dollar-RMB NDF market between 2004 and 2006 was mainly caused by the fact that participants in this market do not have access to the RMB money market and hence were facing different interest rates from the onshore interest rates used for CIP calculation. More recently, scholars have found empirical evidence showing CIP deviation in the offshore market is a significant determinant of China's capital flight (Cheung & Qian 2010).

In light of the above documentations, it is surprising that the onshore interbank market received very little academic attention up to now. In fact, Wang (2010) appears to be the first documentation of CIP violations in the onshore interbank forward market. Because participants in the onshore market have access to onshore RMB money market, the hypothesis proposed by Ma & McCauley (2008) to explain CIP deviation in the offshore market should not apply to onshore market. Wang (2010) hypothesizes that CIP deviations in the onshore market are 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, other than presenting evidence that Chinese authorities indeed impose conversion restrictions in the spot market which coincide with the

observed CIP deviations, Wang (2010) provides no theoretical argument on why conversion restrictions are imposed, how the level is determined, and 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 from happening. In particular, SAFE has the legal authority to review all foreign exchange transactions taking place in the interbank market. Consequently, no interbank spot transaction can legally take place 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 to take place, both parties need to submit proof that such transaction is a current account transaction (i.e., linked to trading needs). If the transaction is a capital account transaction, then the parties have to show that this particular capital account transaction is in line with capital control policies. Unfortunately, a forward trader's attempt to cover his forward position might appear to be a capital account transaction to SAFE and consequently faces a strictly positive probability of his covering effort being denied, resulting in CIP deviations in forward pricing.

Given that this paper attempts to determine theoretically how conversion restrictions lead to CIP deviations, it is essential to review some existing models used to explain CIP deviation and determine whether these models (or modifications thereof) can be applied to China's case. Unfortunately, existing models used to study CIP deviations do not assume severe and persistent conversion restrictions in the foreign exchange market, so there are no off-the-shelf models that I can use directly. Granted, the

assumption of no conversion restriction in the spot market is justified in light of the markets for which these models were built to study. Indeed, models attempting to explain persistent arbitrage opportunities in well-established securities markets today (some of which deals directly with CIP deviations while others can be applied to the study of CIP deviations) normally focus on more subtle causes such as different default risk between counterparties (Duffie & Huang 1996, Baba & Packer 2009), liquidity constraints, and margin constraints (Garleanu & Pederson 2009) rather than focusing on conversion restrictions in the spot market. Because conversion restriction has not been a relevant factor in well established foreign exchange markets in recent memory, it also renders many attractive models currently being employed to explain CIP deviation less suitable for my investigation. In particular, the models described above do not consider artificially imposed capital controls imposed by the government in any form, let alone conversion restrictions in the spot market.

Persistent CIP deviations due to capital controls have been studied in the past. A seemingly relevant case appears to be when Germany imposed various controls on capital inflows between 1970 and 1974. These controls resulted in CIP deviations in the forward market that reflected an arbitrage opportunity of purchasing marks spot, investing mark balance in German bank deposits, and selling marks forward (Dooley & Isard 1980).

Although at first glance the situation experienced by Germany in the early 1970s highly resembles China's situation recently both in the direction of arbitrage opportunity and in the fact that CIP deviations were caused by controls placed on capital inflow, a closer investigation reveals that the forms of capital control placed by the two countries are inherently different. In particular, the German capital control measures primarily

involved lowering interest rates earned on German mark by foreign residents, so the friction is introduced in the German money market such that foreigners would earn lower interest rates on their German currency than domestic residents. This is not the case in China's interbank market, where banks, regardless foreign or domestic, face similar interest rates for their RMB proceeds.³ As mentioned above, China's control on capital flow takes the form of conversion restriction in the spot market. Although German Bundesbank indeed intervened in the spot market by selling marks, Germany did not implement policies that denied transactions in the spot market. Hence, models developed to study the German experience cannot be transferred to study the Chinese experience.

If we look farther back in time, scholars have offered the lack of sufficient arbitraging capital as a cause of persistent CIP deviations (Tsiang 1959, Kindelberger 1939), but the lack of arbitrage-seeking capital hypothesis seems less relevant today other than during periods of temporary liquidity constraints.

There was a time during which conversion restrictions were more prevalent. More than half of a century ago, conversion restrictions in foreign exchange markets between dollar and European currencies resulted in persistent CIP deviations during the early 1930s to the late 1950s (Holmes and Schott 1965). Hence, my hypothesis that conversion restrictions were the primary cause for the CIP deviations observed in the dollar-RMB market is not unprecedented. Ironically, when conversion restriction was a prevalent feature in western foreign exchange markets, economists had yet to adopt the practice of building mathematical models to explain the CIP deviations observed. Consequently, there is no readily available model when we want to focus on the questions of why China wants to impose conversion restrictions, how it determines the

³ Conditional on the banks in comparison have similar credit risk

level of conversion restrictions, and how conversion restrictions in the spot market impacts the determination of forward rate. Hence, a new model is needed to address these seemingly old questions, and I present such a model in this paper.

The main findings are: 1. China imposes conversion restrictions to achieve balance in capital flows, but face the trade off of potentially disturbing current account transactions associated with trade, and conversion restrictions in the spot market indirectly alters the market's expectation of future spot rate. In particular, the level of conversion restriction should increase with deviations from uncovered interest rate parity (UIP) and should decrease with net export. 2. When conversion restrictions are present, interbank forward rate is a weighted average of two prices: the CIP-implied forward rate and the expectation of future spot rate, with the weight reflecting the level of conversion restrictions; and 3. The offshore forward rate reflects the market's expectation of future spot rate. Daily data are used to verify results 2 and 3, and the empirical results are consistent with the model predictions. Although the first result also has empirically testable implications, the current draft of this paper does not include such tests.

The remaining of this paper is organized in the following fashion. Section 2 provides background information on the relevant markets. Hopefully the descriptions will render certain assumptions in the model more justifiable. Section 3 sets up the model and discusses its theoretical and empirical implications. Section 4 describes the data. Section 5 presents the empirical results. Finally, section 6 concludes and proposes one potential solution to decrease CIP deviation in the onshore market while maintaining conversion restrictions in the spot market.

2. Background Information

2.1 Retail Dollar-Yuan Forward Markets

The retail dollar-yuan forward markets are offshore markets and the forward contracts traded in the retail markets are non-deliverable forwards. A non-deliverable forward is conceptually similar to an outright forward contract. A notional principal amount, the forward rate, and maturity date are all specified in the contract. On maturity, the two parties do not exchange the currencies. Instead, only a net settlement will be made to reflect the difference between the agreed forward rate and the actual spot rate on maturity. In the case of dollar-yuan retail forwards, the difference is cash-settled in dollars.

There are currently two highly active retail dollar-yuan forward markets: Hong Kong and Singapore. The Singapore retail market dates back to December 1998 while the Hong Kong retail market did not pick up until October 2005.⁴ This paper focuses on the Hong Kong market. In October 2005, Hong Kong launched retail dollar-yuan non-deliverable forward contracts. The contracts are offered for a minimum of \$10,000. The relative small subscription size of these contracts caters to the hedging needs of small and medium-sized enterprises with RMB exposures in addition to large enterprises.

Different from the retail non-deliverable forward contracts of Singapore, forward maturity and price for the contracts offered in Hong Kong are standardized rather than individually negotiated between offering banks and investors. At the time of introduction of such retail forward contracts, Hong Kong Monetary Authority had designated sixteen banks to offer this service.⁵

⁴ There were some OTC trading of forward contracts in Hong Kong prior to October 2005, but the volume was small and estimated to be 5% of all non-deliverable RMB forward contracts (Fung et al. 2004)

⁵ The sixteen banks are: Bank of China, Bank of Communications, Bank of East Asia, Chiyu Bank, Citibank (Hong Kong), DBS Bank, Fubon Bank, Hang Seng Bank, HSBC, Industrial & Commercial Bank

For example, Nanyang Commercial Bank is one of the 16 banks designated to be a market maker in this retail forward market. It offers this product to its customers free of charge. Yet, the customer is required to post certain amount of collateral. Customers can choose to use different types of deposit as the collateral, including fixed deposit, foreign currency savings, Hong Kong dollar savings, current deposits or RMB savings. The minimum contract size is \$10,000 and there is no upper limit on the number of contracts a customer can enter.

First, the forward rates of various maturities are made available to the customers. Customers then decide to buy or sell RMB forward base on their hedging needs. At maturity, settlement amount is equal to contract notional amount x [1-forward rate/settlement rate]. The settlement rate is defined as the official closing exchange rate for RMB against the U.S. dollar as announced by the People's Bank of China on valuation date. If the settlement amount is greater than zero, then the seller of dollar shall pay the settlement amount to the buyer. If the settlement amount is less than zero, then the buyer of dollar shall pay the settlement amount to the seller. Foreign currency savings account (usually a U.S. dollar savings account) is used for settlement purpose. If customers do not have foreign currency savings account, his/her Hong Kong Dollar savings account, current account or RMB saving account will be considered as settlement account after currency conversion.

2.2 Wholesale Dollar-Yuan Spot and Forward Markets

The official interbank foreign exchange market in China is called China Foreign Exchange Trade System (CFETS). It is the only legal market for interbank foreign

of China, Liu Chong Hing Bank, Nanyang Commercial Bank, Royal Bank of Scotland, Shanghai Commercial Bank, Standard Chartered Bank, and Wing Lung Bank. Information regarding the Hong Kong retail non-deliverable forward market is reported by a China Daily article dated September 27, 2005.

exchange activities in China, and participation is restricted to members only. It was initially founded in February 1994, which marked the unification of the highly fragmented inter-bank foreign exchange markets in China. CFETS headquarter is in Shanghai, with a backup headquarter in Beijing. In addition, it also has 18 sub-centers.⁶ It is a sub-department of People's Bank of China (PBoC), and is also regulated by the State Administration of Foreign Exchange (SAFE).

All foreign exchange transactions are required to occur in CFETS during its market-hours,⁷ hence no after hour trading is allowed. Currently, the products being traded on CFETS include spot trading, deliverable forward contracts between RMB and USD, and currency swaps between RMB and other foreign currencies. For the spot market, the major currencies involved are RMB, US dollar, Sterling, Hong Kong Dollar, Yen, and Euro. Forward contracts between RMB and US dollar were first introduced in October 2005, less than 3 months after China ended its decade long pegging regime. There are currently 279 members in the spot market and 69 members in the forward market (CFETS 2009b).⁸ Out of the existing members, there are 16 that serve as primary market makers in both spot and forward markets.⁹ Out of these 16 members, 6 are also market makers in the retail forward market.¹⁰

Spot trade in CFETS can occur in two ways. The first one is that traders reports an order (price and volume) into an electronic system, then the computer matches the

⁶ The 18 cities are Guangzhou, Shenzhen, Tianjin, Jinan, Dalian, Nanjing, Xiamen, Qingdao, Wuhan, Chongqing, Chengdu, Zhuhai, Shantou, Fuzhou, Ningbo, Xian, Shenyang, and Haiko

⁷ 9:30-15:30 Monday through Friday with the exception of holidays

⁸ As of 11/24/2009

⁹ The 16 primary market makers are: Australia and New Zealand Banking Group; Bank of China; Bank of Montreal; Bank of Tokyo-Mitsubishi UFJ; Banque Indosuez; BNP Paribas; China CITIC Bank; China Construction Bank; Citi Bank; Deutsche Bank; HSBC; Industrial and Commercial Bank of China; ING Bank; Standard Chartered Bank; UBS; Royal Bank of Scotland.

¹⁰ Bank of China, Citibank, HSBC, Industrial & Commercial Bank of China, Standard Chartered Bank, Royal Bank of Scotland.

highest bid and the lowest ask. Traders can also log into this system without reporting an order to obtain quotes and follow the market. The second way is by individual negotiation. Members can directly trade with a market maker or with any other member, all transactions have to be approved by SAFE prior to its execution and the final transaction will be reported for record keeping. For forward contracts and currency swaps, only the second method is allowed.

Chinese authorities intervene heavily in the foreign exchange spot market. Take the dollar-yuan spot market for example, the PBoC sets the opening quote based on the previous day's closing price and allows a narrow range of daily fluctuation. When supply and demand forces require the market clearing price to go beyond the fluctuation range, the PBoC steps in to buy (or sell) dollars to maintain the exchange rate within the band. At the end of the trading day, the PBoC also announces the official closing rate. Another way of intervention comes from SAFE monitoring, which has already been discussed in Introduction.

Forward contracts in this market are deliverable contracts with standardized maturities.¹¹ Yet, a forward contract in the wholesale market can be settled in two ways: gross settlement and net settlement. Under gross settlement, full notional amounts of the yuan and dollar are exchanged on delivery date (i.e. contract maturity date). Under net settlement, counter parties only settle the difference between the forward rate and settlement rate. The net settlement can be settled in either dollar or RMB, which is agreed upon in advance. The settlement rate is defined as the closing rate two days prior to

¹¹ Forward contracts of 1 week, 1 month, 3 month, 6 month, 9 month, and 12 month are traded. Forwards with longer maturities do exist, but are less liquid.

maturity date. Settlement method is agreed upon in advance by the two counter parties when they enter into the contract.

Counterparties in the forward contracts can require collaterals from each other. The collateral amount, delivery date, and returning date are determined by the two counterparties on a case-by-case basis. The CFETS can provide the safekeeping service and hold the collaterals if the two counter parties desire such arrangement. Yet, CFETS does not require the posting of collaterals. Collateral can be denominated in any currency as long as the two parties agree. Although exact figures are not available, one would guess that for dollar-yuan forward contracts, the collateral currencies (if any) are dollar and/or RMB.

The primary purpose of these interbank forward contracts is to allow banks to provide better hedging instruments to their customers (CMPR 2007Q2)¹². Hence, it appears that the intended objective of the interbank wholesale forward market is to allow banks to cover any net forward positions they have accumulated in the retail market with their customers.

2.3 China's Interbank Money Market

The official interbank money market for RMB borrowing and lending is the National Interbank Funding Center (NIFC). The NIFC was officially established in January 1996, under a mandate by the PBoC that required all inter-bank borrowing and lending activities be carried out via the NIFC. Furthermore, on January 3rd 1996, NIFC and CFETS became de facto one market in the sense that both locate in the same physical location and use the same operating system. Finally, the de facto combination of NIFC

¹² “CMPR” is short for China Monetary Policy Report, see reference for further details

and CFETS is officially recognized by a PBoC mandate on January 27, 1997. Hence, both CFETS and NIFC are regulated by the PBoC and treated as one entity.

For unsecured lending and borrowing among financial institutions, the relevant interest rate is the Shanghai Interbank Offered Rate (Shibor). Conceptually, Shibor is equivalent to Libor with the exception that the market is physically located in Shanghai instead of London. In particular, it is a simple, no-guarantee, wholesale interest rate calculated by arithmetically averaging all the interbank RMB lending rates offered by the price quotation group of banks with a high credit rating. There are currently 16 banks in the quoting group.¹³ Although all Shibor-reporting banks are participants in the CFETS, only 6 of them are also primary market makers in CFETS. In addition, only 5 are market makers in the retail forward market. The intersection of all three lists consists of 4 banks: Bank of China, HSBC, ICBC, and Standard Chartered.

Shibor is calculated by removing the top 2 and bottom 2 rates and then averaging the remaining 12 quotes. Currently, the Shibor survey banks are required to provide rates on the following eight maturities: overnight, 1-week, 2-week, 1-month, 3-month, 6-month, 9-month and 1-year. In addition to the required rates, reporting banks also have the option to report any of the following eight maturities: 3-week, 2-month, 4-month, 5-month, 7-month, 8-month, 10-month, and 11-month. The rates are quoted in percentage as annual rates using 360 days per year and retain four digits after the decimal.

3. The Model

¹³ The 16 reporting banks for 2009 are: Agricultural Bank of China; Bank of Beijing; Bank of China; Bank of Communications; Bank of Shanghai; China CITIC Bank; China Construction Bank; China Everbright Bank; Shanghai Pudong Development Bank; China Merchants Bank; HSBC; Huxia Bank; Industrial and Commercial Bank of China; Industrial Bank Co., Ltd.; Postal Savings Bank of China; Standard Chartered Bank.

3.1 Basic Setup and Theoretical Results

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.

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 of the two currencies as exogenously given.

The spot market functions as the following. Every period, the announcer announces a spot price (S_t).¹⁴ Everyone who wants to engage in a spot transaction has to trade with the announcer.¹⁵ In addition, the announcer can refuse to trade on any particular transaction, leaving that particular participant unable to complete his transaction.

As mentioned in the Introduction, the announcer wants to reject trades in an attempt to achieve capital flow balance. Assume that the net supply of dollar in period t (H_t) in the spot market can be described by the following equation.

$$H_t = aX(S_t) + f\left(\frac{S_t}{E_t[S_{t+1}]} \frac{1+i_{RMB,t}}{1+i_{\$,t}} - 1\right).$$

$X(S_t)$ represents the amount China's net export to the U.S. as function of the exchange rate. Given that exporters with dollar revenue might not want to convert all of their dollar revenue into RMB, let us assume $a \in [0, 1]$. Given that dollar supply from $X(S_t)$ is trade

¹⁴ One can think of the announcer as the PBoC.

¹⁵ Alternatively, one can picture the announcer matching orders at the announced price, and then function as the counterparty to the unmatched orders. For example, at the announced price, if the quantity of dollar supplied is greater (less) than the quantity of dollar demanded, the announcer will buy (sell) dollar such that supply equals demand.

related by construction, the quantity $aX(S_t)$ represents current account transactions. The second component of H_t represents capital account transactions, which is primarily driven by anticipated appreciation of the RMB and interest differentials between the two countries. Assuming that $f' \geq 0$, then if the rate of expected RMB appreciation increases relative to the interest differential, then more capital will flow into China and hence increase the amount of dollar being supplied in the spot market.¹⁶

Let us focus on the case in which the announcer announces a spot rate that results in more dollars being supplied than demanded because this is the more relevant case. In particular, there is net capital inflow ($f > 0$) and net export ($aX(S_t) > 0$). In such a scenario, the announcer has the option to reject some dollar selling orders. Yet, he does not want to block dollar selling orders in a non-discriminating fashion. Instead, he wants to curb capital inflow (i.e., decrease f) without interfering with the current account transactions ($aX(S_t)$). If the announcer is omniscient and can perfectly distinguish current account transactions from capital account transactions, then he can achieve his objective without difficulty. However, let us assume that the announcer does not have perfect information. Imagine that the announcer first identifies the selling orders that he suspects to be capital account transactions and then has to decide what fraction ($\alpha_t \in [0,1]$) does he want to reject while knowing that some of the transactions on his list of suspects are actually current account transactions. Consequently, he faces a trade off

¹⁶ For simplicity, assume that $f(0) = 0$, which reflects the fact that there will be zero capital flow when excessive return of Chinese investments over U.S. investments is exactly offset by expected RMB appreciation/depreciation. The function f takes on negative values when expected RMB appreciation is less than the interest rate differential between China and U.S., which would reflect capital flowing out of China and hence decrease the dollar supply in the spot market.

between rejecting more capital account transactions (which he likes) and rejecting more current account transactions (which he dislikes). Furthermore, assume that the announcer's objective function when determining α_t is the following:

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

$$\min_{\alpha_t \in [0,1]} (1-\alpha_t) \left| f \left(\frac{S_t}{E_t[S_{t+1}]} \frac{1+i_{RMB,t}}{1+i_{\$,t}} - 1 \right) \right| + \lambda g(\alpha_t) |aX(S_t)|, \text{ where } g: [0,1] \rightarrow [0,1] \text{ is the}$$

announcer's mistake function and $\lambda \geq 0$ is the cost he attaches to his mistake.

Furthermore, assume that $g(\alpha_t) \leq \alpha_t$, $g'(\alpha_t) > 0$, $g''(\alpha_t) > 0$, and $g'(0) = 0$. The interpretation is that the more transactions he denies, the chance of him incorrectly denying a current account transaction increases, and he is more likely to make mistake the more aggressive he is with his denying effort. Hence, although he would like to achieve capital account balance by picking $\alpha_t = 1$, he cannot do this because he also does not want to disturb current account transactions.

Taking the first order condition, we obtain that the level of convertibility constraint in the spot market is determined by the following equation.

$$(1) \quad g'(\alpha_t) = \frac{\left| f \left(\frac{S_t}{E_t[S_{t+1}]} \frac{1+i_{RMB,t}}{1+i_{\$,t}} - 1 \right) \right|}{\lambda |aX(S_t)|}$$

An immediate implication of Equation (1) is that level of conversion restriction should be increasing with absolute value of UIP deviation and decreasing with net export. In addition, within the current set up, net dollar supply in the spot market becomes

$$(2) \quad H_t = (1-g(\alpha_t))aX(S_t) + (1-\alpha_t) f \left(\frac{S_t}{E_t[S_{t+1}]} \frac{1+i_{RMB,t}}{1+i_{\$,t}} - 1 \right).$$

Notice that the announcer can achieve a targeted spot rate in a combination of two ways: Function as the counterparty for all unmatched orders ($H_t \neq 0$), and/or deny some unmatched orders ($\alpha_t > 0$). In every period, the announcer announces S_t which the model takes as exogenously given. Base on this S_t , he determines α_t according to Equation (1), and then determines H_t according to (2) by trading with any remaining unmatched orders.

Under this set up, one can conceptualize the “true” market clearing exchange rate (S_t^*), which is the exchange rate when the announcer does not intervene in any of the ways mentioned above (i.e., $H_t = 0$ and $\alpha_t = 0$). Hence, S_t^* is implicitly defined by Equation (3).

$$(3) \quad 0 = aX(S_t^*) + f\left(\frac{S_{t+1}^*}{E_t[S_{t+1}]} \frac{1 + i_{RMB,t}}{1 + i_{\$,t}} - 1\right)$$

Compare (2) and (3), one should notice that any discrepancy between S_t and S_t^* is generated by $H_t \neq 0$ and/or $\alpha_t > 0$.

With respect to S_t^* , I am assuming that uncovered interest rate parity (UIP) holds.

$$(4) \quad E_t[S_{t+1}^*] = \frac{1 + i_{RMB,t}}{1 + i_{\$,t}} S_t^*$$

Essentially, $E_t[S_{t+1}^*]$ is the market’s expectation of next period’s spot rate conditional on no intervention from the announcer. However, given that the announcer might intervene next period as well, the market’s unconditional expectation of next period’s spot rate ($E_t[S_{t+1}]$) should be somewhere in between the current spot rate (S_t) and $E_t[S_{t+1}^*]$. One end reflects the belief that the announcer will maintain a peg and keeps

the spot rate constant next period ($E_t[S_{t+1}] = S_t$) while the other end reflects the belief that the announcer will stop all forms of intervention ($E_t[S_{t+1}] = E_t[S_{t+1}^*]$).¹⁷

$$(5) \quad E_t[S_{t+1}] = (S_t)^{\sigma_t} E_t[S_{t+1}^*]^{1-\sigma_t}, \text{ where } \sigma_t = \sigma(E_t[\alpha_{t+1}], E_t[H_{t+1}]).$$

Equation (5) says that the expected spot rate is between S_t and $E_t[S_{t+1}^*]$, and the weight depends on the expectation of future intervention levels ($E_t[\alpha_{t+1}], E_t[H_{t+1}]$), which in turn depends on the current levels of intervention. I assume $\sigma(0,0) = 0$ to ensure $E_t[S_{t+1}] = E_t[S_{t+1}^*]$ when the market expects no intervention in the spot market next period.

Let us now shift to the forward markets. In the forward markets, both retail and interbank, counterparties agree on the exchange rate of period t+1 in period t.

In the retail market, retail banks would announce the retail forward price ($F_{ND,t}$). Taking $F_{ND,t}$ as given, retail customers enter into forward contracts with retail banks base on their hedging needs, and retail banks realize whether they are net dollar buyers or net dollar sellers in the retail forward market. Each retail bank decides whether it would like to cover its net position. If yes, it decides whether it will cover via the wholesale market or internally. For example, if a retail bank has established a net forward position to deliver yuan and receive dollar next period, then it can cover this position by entering into a forward contract to deliver dollar and receive yuan in the interbank forward market. Alternatively, it can cover internally by borrowing dollar, buy RMB in the spot market, and lend the RMB proceeds.

¹⁷ I am implicitly assuming that the announcer will only move the spot rate in the direction of the expected “true” spot rate next period and would not move the exchange rate in the opposite direction of the expected “true” spot rate.

The retail customers do not have access to the interbank money markets of either currency nor to the interbank forward foreign exchange markets.

The objective of any retail bank is to announce a forward rate that would maximize its expected profit while taking the spot exchange rate (S_t), interbank interest rates for the two currencies ($i_{RMB,t}, i_{\$,t}$), convertibility constraint (α_t), and the current expectation of future spot rate conditional on all currently available information ($E_t[S_{t+1}]$) as given. In addition, when announcing $F_{ND,t}$, retail banks are completely agnostic about whether they will become net buyers or net sellers in the retail market. In particular, they do not know the probability distribution function of their net positions in the retail market and act under the belief that their choice of $F_{ND,t}$ cannot influence the probability distribution function.

In the interbank forward market, participants are also trying to maximize expected profit. Forward contracts can be traded between any pair of participants, and all participants have access to the spot market and the two money markets. In particular, Trade can occur at forward prices ($F_{D,t}$) only if expected profits of both counterparties are weakly greater than zero.

The announcer imposed convertibility constraint impacts the forward markets. In particular, assume that transactions associated with internally covering a forward appear to the announcer as capital account transactions and hence face probability α_t of being denied. Consequently, $\alpha_t = 0$ means the ability to fully cover a forward contract (i.e., no covering difficulty) in period t and $\alpha_t = 1$ means that a forward contract cannot be hedged internally at all in period t. In addition, if a trader cannot hedge part of his forward

position in period t because of the convertibility constraint, he would need to use the spot market in period $t+1$ to obtain the necessary currency (either dollar or RMB) to fulfill his forward contract, facing an expected exchange rate of $E_t[S_{t+1}]$. Assume that his spot transaction in period $t+1$ associated with the fulfillment of his forward obligation would face no convertibility constraint because it will be viewed as a current account transaction to the announcer.

Proposition 1: Wholesale forward pricing is described by Equation (6)

$$(6) \quad F_{D,t} = (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}], \text{ where } F_{CIP,t} \equiv S_t \frac{1 + i_{RMB,t}}{1 + i_{\$,t}}$$

Proof:

First consider the case of $F_{CIP,t} > E_t[S_{t+1}]$. For the party that buys dollar forward (dollar forward buyer), he will gain $F_{CIP,t} - F_{D,t}$ in period $t+1$ for the fraction of the forward contract he can internally cover. For the fraction that he cannot cover due to the announcer-imposed convertibility constraint, his expected payoff in period $t+1$ is $E_t[S_{t+1}] - F_{D,t}$. Given that he wants to maximize 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

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

$$(6.1) \quad F_{D,t} \leq (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$$

The dollar forward seller wants to have $F_{D,t}$ as high as possible, but he understands that if he demands $F_{D,t} > (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$, his counterparty would refuse to trade.

If the seller asks for $F_{D,t} = (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$, then such a price is still acceptable to the buyer and trade will occur.

For the case of $F_{CIP,t} \leq E_t[S_{t+1}]$, the argument is similar.

The dollar seller in this transaction will enter into such a contract if and only if

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

$$(6.2) \quad F_{D,t} \geq (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$$

The dollar buyer wants to have $F_{D,t}$ as low as possible, but there will simply be no seller if (6.2) is violated. Because there are many potential sellers, price will be pushed down to $F_{D,t} = (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$.

QED.

Proposition 1 says that when a forward position cannot be fully covered internally due to conversion restrictions, the forward price deviates 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, then forward price equals $F_{CIP,t}$, which is very straightforward because convertibility restriction is the only friction considered in my model. On the other hand, if a forward cannot be covered internally at all, forward price is determined solely by the expectations of future spot price. Finally, when a forward can only be partially covered internally, its pricing depends on the weighted average of $F_{CIP,t}$ and $E_t[S_{t+1}]$.

Now that we have resolved the question of how wholesale forwards are priced, we turn next to the question of locating an observable measure 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 wholesale forward market.

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

Proof:

If a retail bank that has accumulated a net dollar-buying position in the retail forward market and decides to cover via the wholesale forward market, it faces a payoff of $F_{D,t} - F_{ND,t}$. By Proposition 1, this payoff is equal to $(1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}] - F_{ND,t}$ ¹⁸.

If it does not cover its retail position, then its expected payoff is $E_t[S_{t+1}] - F_{ND,t}$. Given that the retail bank is risk neutral, it only cares about the expected payoffs when deciding whether or not to cover. Consequently, it covers its retail position if and only if

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

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

QED

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

¹⁸ If the retail bank decides to cover its position internally, it would also receive this payoff.

Proposition 3: (7) $F_{ND,t} = E_t[S_{t+1}]$.

Proof:

When a retail bank announces $F_{ND,t}$, it takes $F_{CIP,t}$ and $E_t[S_{t+1}]$ as given. So 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 dollar in the retail market would cover its position while a retail bank with a net position to buy dollar in the retail market would not cover its position. Because retail banks do not know the probability distribution of whether they will become net buyers or net sellers of dollar in the retail forward market, 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 would announce $F_{ND,t}$ such that $E_t[S_{t+1}] - F_{ND,t} \geq 0$. Conditional on being a net seller of dollar 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 banks optimization problem prior to it

finds out whether it is a net buyer or net seller of dollar in the retail market can be summarized as 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 $F_{ND,t} = E_t[S_{t+1}]$.

The case of $F_{CIP,t} > E_t[S_{t+1}]$ can be analyzed in a similar fashion with a few minor changes. Assume that $F_{CIP,t} > E_t[S_{t+1}]$, then by Proposition 2, a retail bank with a net position to sell dollar in the retail market would not cover its position while a retail bank with a net position to buy dollar in the retail market would cover its position. Once again, retail banks focus on the expected payoff conditional on their net positions when determining $F_{ND,t}$.

Conditional on being a net seller of dollar in the retail market, a retail bank's expected payoff is $F_{ND,t} - E_t[S_{t+1}]$. Conditional on being a net buyer of dollar in the retail market, the retail bank's payoff is $(1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}] - F_{ND,t}$. Consequently, the retail banks optimization problem prior to it finding out whether it is a net buyer or net seller of dollar in the retail market can be summarized as $\max_{F_{ND,t}} (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}] - F_{ND,t}$ such that $F_{ND,t} - E_t[S_{t+1}] \geq 0$. The solution to this maximization problem is also $F_{ND,t} = E_t[S_{t+1}]$.

Finally, when $F_{CIP,t} = E_t[S_{t+1}]$, a retail bank with a net position in the retail market would cover regardless of the direction of its net position. Conditional on being a net buyer of dollar 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 dollar 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 $F_{ND,t} = E_t[S_{t+1}]$.

QED

I hereby summarize my model for reference ease.

The model has 4 exogenous variables:

1. $i_{RMB,t}$ = RMB interbank interest rate from period t to t+1
2. $i_{\$,t}$ = US dollar interbank interest rate from period t to t+1
3. S_t = Spot rate announced in period t
4. $F_{CIP,t} \equiv S_t \frac{1 + i_{RMB,t}}{1 + i_{\$,t}}$

The model has 7 endogenous variables:

1. α_t = Convertibility constraint during period t
2. H_t = Level of intervention in the form of the announcer fulfilling unmatched orders in the spot market
3. S_t^* = market clearing RMB-per-dollar exchange rate if there is no intervention from the announcer
4. $E_t[S_{t+1}^*]$ = Market expectation of the spot rate next period conditional on no intervention of any form
5. $E_t[S_{t+1}]$ = Market expectation of the spot rate next period
6. $F_{ND,t}$ = Non-deliverable forward rate (retail forward rate)
7. $F_{D,t}$ = Deliverable forward rate (interbank forward rate)

Seven equations that go with the 7 endogenous variables:

$$(1) \quad g'(\alpha_t) = \frac{\left| f\left(\frac{S_t}{E_t[S_{t+1}]} \frac{1+i_{RMB,t}}{1+i_{\$t}} - 1\right) \right|}{\lambda |aX(S_t)|}$$

$$(2) \quad H_t = (1 - g(\alpha_t))aX(S_t) + (1 - \alpha_t) f\left(\frac{S_t}{E_t[S_{t+1}]} \frac{1+i_{RMB,t}}{1+i_{\$t}} - 1\right)$$

$$(3) \quad 0 = aX(S_t^*) + f\left(\frac{S_{t+1}^*}{E_t[S_{t+1}]} \frac{1+i_{RMB,t}}{1+i_{\$t}} - 1\right)$$

$$(4) \quad E_t[S_{t+1}^*] = \frac{1+i_{RMB,t}}{1+i_{\$t}} S_t^*$$

$$(5) \quad E_t[S_{t+1}] = (S_t)^{\sigma_t} E_t[S_{t+1}^*]^{1-\sigma_t}$$

$$(6) \quad F_{D,t} = (1 - \alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$$

$$(7) \quad F_{ND,t} = E_t[S_{t+1}]$$

3.2 Empirical Implications

Implication 1: If Proposition 3 or Equation (7) is indeed correct, then by the law of large numbers, $\lim_{n \rightarrow \infty} \frac{1}{n} \sum_{t=1}^n (F_{ND,t} - S_{t+1}) = 0$.

Implication 2: An immediate implication of Proposition (1) or Equation (6) is that two conditions have to hold for $F_{D,t}$ to violate CIP. The first is $E_t[S_{t+1}] \neq F_{CIP,t}$. The second is $\alpha_t > 0$. Without the first condition, $F_{D,t}$ has no room to deviate from CIP.

Without the second condition, traders will not incorporate $E_t[S_{t+1}]$ into their determination of $F_{D,t}$. Yet, we see from Equation (1) that α_t is increasing in the gap 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. If we combine this

implication with Proposition 3 or Equation (7), which states that offshore forwards is a measure of spot rate expectation, then correlation between CIP deviations from offshore and onshore markets should be positive because CIP deviations in the offshore market is equivalent to UIP deviations in this model.

Implication 3: Combine the results of Proposition 1 and Proposition 3, the following relationship can be obtained: $F_{D,t} = (1 - \alpha_t)F_{CIP,t} + \alpha_t F_{ND,t}$, which says that the forward price in the interbank wholesale 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 a regression.

Regression (1)
$$F_{D,t} = \beta_1 F_{CIP,t} + \beta_2 F_{ND,t} + \varepsilon_t$$

Hence, conditional on the assumption that covering difficulty does not change during a time interval, α_t can be estimated by $\hat{\beta}_2$ from Regression (1). Even if the level of convertibility restriction did change over the sample period, $\hat{\beta}_2$ 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-announcement and post announcement using May 18, 2007 as the dividing line—should generate $\hat{\alpha}_{post} > \alpha_{pre}$ if the hypothesis is correct. In addition, the model predicts $\hat{\beta}_1 + \hat{\beta}_2 \approx 1$. Hence, whether the two coefficients add up to 1 can serve as another checkpoint for the validity of the model.

[Note: The three implications above can be tested with data I already have. The implications below are potentially interesting directions to explore, but they are just ideas

at this stage and I need to solicit feedback on whether pursuing any of them would be a good idea].

Additional Implications: According to Equation (1), α_t should be inversely related to net export volume. This can potentially give rise to the following empirical tests:

1. Estimates of monthly average of convertibility restrictions can be obtained using Regression (1). Using these estimates and monthly trade data between China and U.S. over the same time interval, one can see if the two series are indeed negatively correlated as Equation (1) would suggest.
2. Given that conversion restrictions drive onshore CIP deviations according to my model, another model prediction is onshore CIP deviation and net export volume should be negatively correlated.
3. Perhaps running the following regression

Regression (2) $\ln(\hat{\alpha}_t) = \beta_0 + \beta_1 \ln(|X_t|) + \beta_2 \ln\left(\left|\frac{F_{CIP,t}}{F_{ND,t}} - 1\right|\right) + \varepsilon_t$ using monthly averages

of convertibility constraint and monthly averages of offshore CIP deviation (which is equivalent to UIP deviation according my model), and we should expect $\hat{\beta}_1 < 0$ and $\hat{\beta}_2 > 0$.

4. Data Description

With respect to forward rates of both NDF and DF, I obtain daily observations from October 19, 2005¹⁹ to February 5, 2010. The NDF rates are from Hong Kong NDF

¹⁹ The first day DF was introduced in CFETS.

market and the source of DF rates is the CFETS. Figures 2 and Figure 3 depict the NDF and DF rates respectively along with the daily closing spot rates announced by SAFE.

<Insert Figures 2 and 3 here>

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

<Insert Figures 4 and 5 here>

Using spot rates and interest rates above, one can calculate the CIP-implied forward rates for various maturities. Figures 6 and 7 illustrate the percentage deviations from CIP exhibited by the onshore and offshore markets respectively.

<Insert Figures 6 and 7 here>

5. Empirical Results

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

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.²⁰ 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 from the sample averages. Given the closeness of the sample averages to zero, there is

²⁰ Given that the averages are measured in RMB.

reason to believe that offshore forward prices are unbiased predictors of future spot price, consistent with Implication 1. [Note: Perhaps include t-test results showing that the means are not significantly different from zero?]

Table 1: $\frac{1}{n} \sum_{t=1}^n (F_{ND,t} - S_{t+1})$ by forward maturities

October 19, 2005-February 5, 2010

	1M	3M	6M	9M	12M
Mean	0.0050	0.0102	0.0149	0.0263	0.0349
Std Dev	0.0314	0.0609	0.1161	0.1730	0.2302
# Obs	1,100	1,056	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 market 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. Instead, realized spot rates were used. The simultaneous violations of CIP and UIP in the dollar-RMB market are also noted 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 8 is a scatter plot of onshore CIP deviation versus offshore CIP deviation (also a measure for UIP deviation) using 12-month forward rates between October 9,

2006 and February 5, 2010. One can easily identify the strong positive correlation between the two series even by visual inspection.

<Insert Figure 8 here>

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**

	1M	3M	6M	9M	12M
Correlation	0.7393	0.8490	0.8959	0.9064	0.9161

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

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 α after that date. Consequently, the sample is divided into two periods: pre-announcement and post-announcement.

Regression (1) $F_{D,t} = \beta_1 F_{CIP,t} + \beta_2 F_{ND,t} + \varepsilon_t$

**Table 3: Regression Results for Regression (1) by Forward Maturities
October 9, 2006-May 17, 2007**

	1M	3M	6M	9M	12M
$\hat{\beta}_1 \approx 1 - \alpha$	0.7855 (0.0593)	0.9067 (0.0280)	0.8938 (0.0167)	0.9275 (0.0105)	0.9567 (0.0097)
$\hat{\beta}_2 \approx \alpha$	0.2148	0.0933	0.1062	0.0718	0.0410

	(0.0594)	(0.0281)	(0.0169)	(0.0107)	(0.0100)
Adj. R ²	0.9921	0.9885	0.9862	0.9870	0.9778
# Obs	137	137	137	137	137

Table 4: Regression Results for Regression (1) by Forward Maturities
May 18, 2006-February 5, 2010

	1M	3M	6M	9M	12M
$\hat{\beta}_1 \approx 1 - \alpha$	0.5716 (0.0142)	0.4175 (0.0133)	0.3209 (0.0119)	0.2566 (0.0118)	0.2562 (0.0102)
$\hat{\beta}_2 \approx \alpha$	0.4276 (0.0142)	0.5814 (0.0134)	0.6782 (0.0121)	0.7438 (0.0121)	0.7434 (0.0106)
Adj. R ²	0.9984	0.9876	0.9600	0.9262	0.8987
# Obs	652	653	653	638	653

Before interpreting the results, one should note that we should not give too much credence to the estimates of average convertibility restriction generated by the shorter-maturity forwards such as the 1-month and 3-month forward. Indeed, reliable estimates of average α_t require that there exists sufficient gap between $F_{CIP,t}$ and $F_{ND,t}$. Take the extreme case of $F_{CIP,t} = F_{ND,t}$ for example, α_t would be undefined and hence cannot be estimated by Regression (1). As Figure 7 reflects, although there are gaps between $F_{CIP,t}$ and $F_{ND,t}$ during the sample periods for the short-duration forwards, the gap is relatively small in comparison to the longer-maturity forwards. Hence, one should focus more on the estimates generated by the 6-month, 9-month, and 12-month forwards.

As mentioned in the previous section, if one has the prior that α_t did not change within a particular time sample, then estimates of Regression (1) will serve as an estimate of α_t during this period. However, if there are reasons to believe α_t did change within a time sample, then Regression (1) can only generate *average* α_t . Prior to the SAFE

announcement on May 18, 2007, one can perhaps argue that the level of conversion restriction was relatively constant because UIP deviations during this period, though present, were relatively less volatile. After the announcement however, the notion that α_t increased once and remained flat at the higher level is less defensible. 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, consistent with what Equation (1) would suggest. Hence, although results from Table 3 can perhaps be argued to represent the level of conversion restriction that was constant prior to SAFE announcement, results from Table 4 should be interpreted as an average of the regularly changing conversion restrictions post announcement.

Under the relatively safer interpretation that results from Regression (1) represents an average of conversion restriction levels within a period, the results are consistent with the hypothesis that SAFE indeed imposed tighter conversion restrictions post its announcement, which is reflected in the significant increase in $\hat{\alpha}$ after the announcement across all forward maturities. Focusing on the longer maturity forwards for which gaps between $F_{CIP,t}$ and $F_{ND,t}$ were quite noticeable even by visual inspection, the high adjusted R^2 measures reflect that variations in $F_{CIP,t}$ and $F_{ND,t}$ can explain a high fraction of the movement in $F_{D,t}$. Furthermore, given that I *did not* restrict the sum of the two coefficients in Regression (1) need to equal 1,²¹ the fact that $\hat{\beta}_1 + \beta_2 \approx 1$ might appear surprisingly good. Nonetheless, it is exactly what the model predicts.

²¹ I did however suppress the constant term.

6. Conclusion

Capital control measures in China, along with any market frictions they generate, are part of life. This paper shows that one particular side effect generated by 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. 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 the level of conversion restriction should be positively related to the absolute level of capital flow and inversely related to the absolute level of net export. 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.

More particularly, the model predicts that onshore forward rate is equal to a weighted average of CIP-implied forward rate and the market's expectation of future spot rate, with the weight determined by the level of conversion restriction. As a secondary result, the model also implies that offshore non-deliverable forwards reflect to the market's expectation of future spot rate. Using daily data between October 9, 2006 and February 5, 2010, empirical results confirm that movements of CIP-implied forward rate and offshore 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 predicting error of future spot rate using offshore forward rate is not economically or statistically significant.

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 a very interesting mechanism design question on and by itself.

Figures

Figure 1:

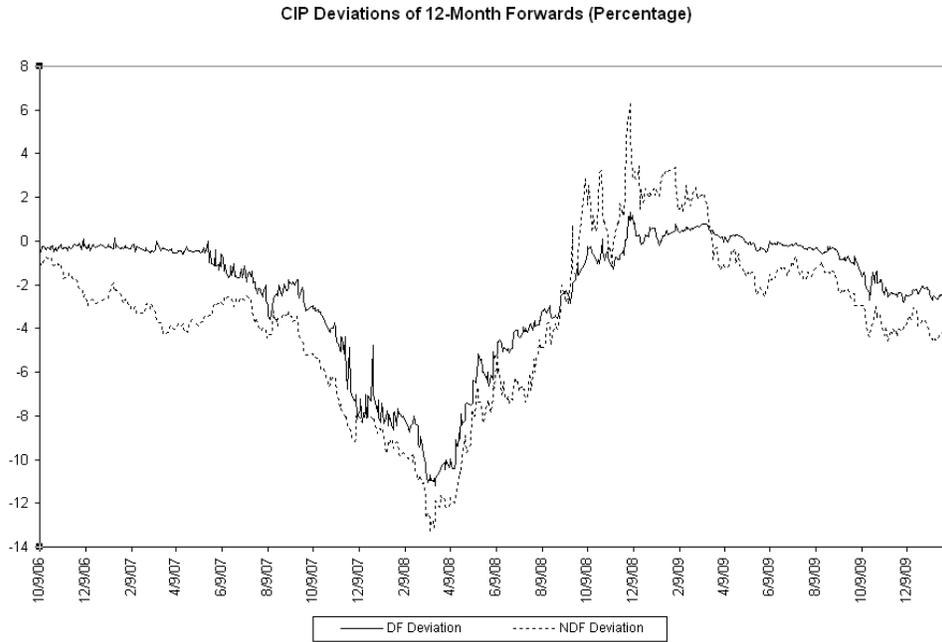


Figure 2:

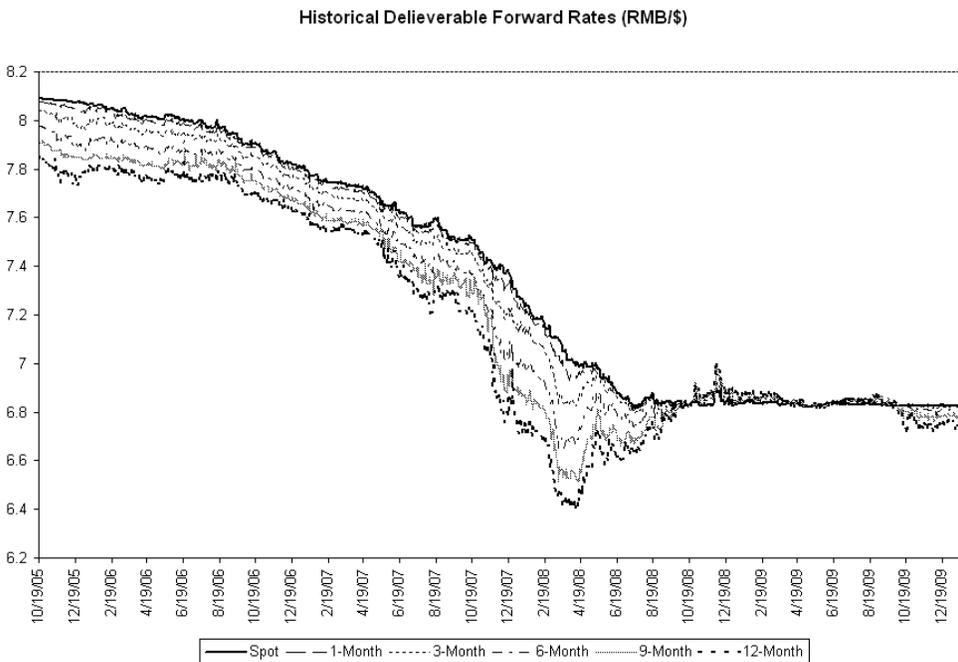


Figure 3:

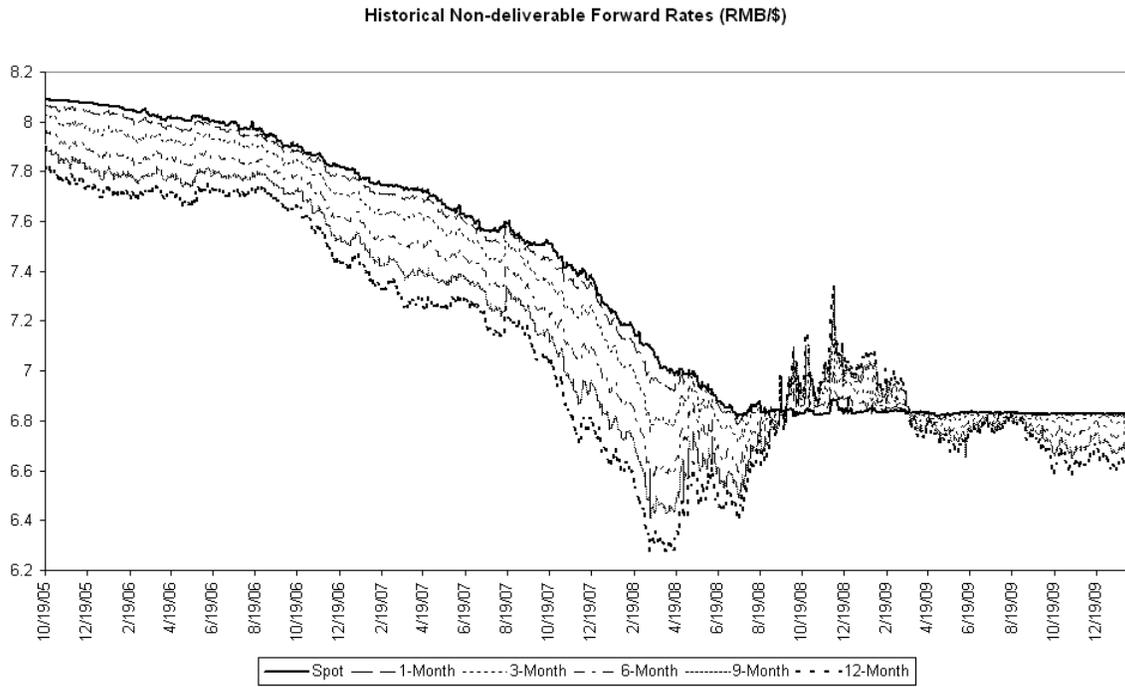


Figure 4:

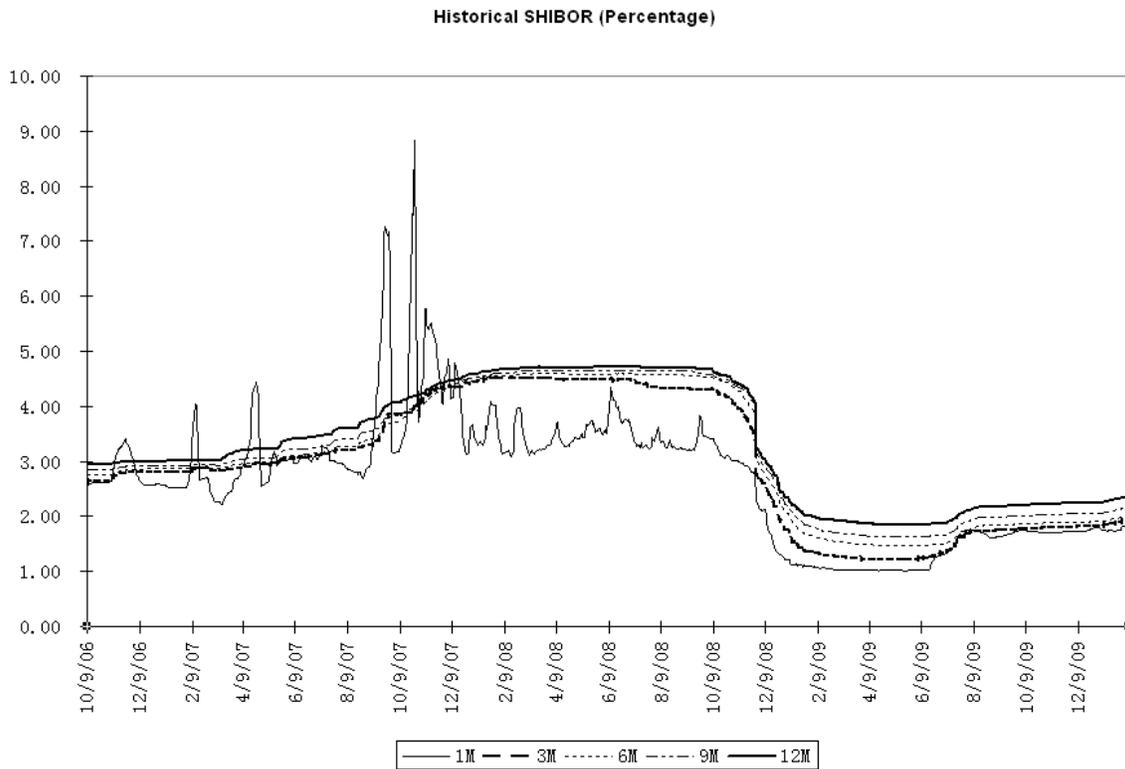


Figure 5:

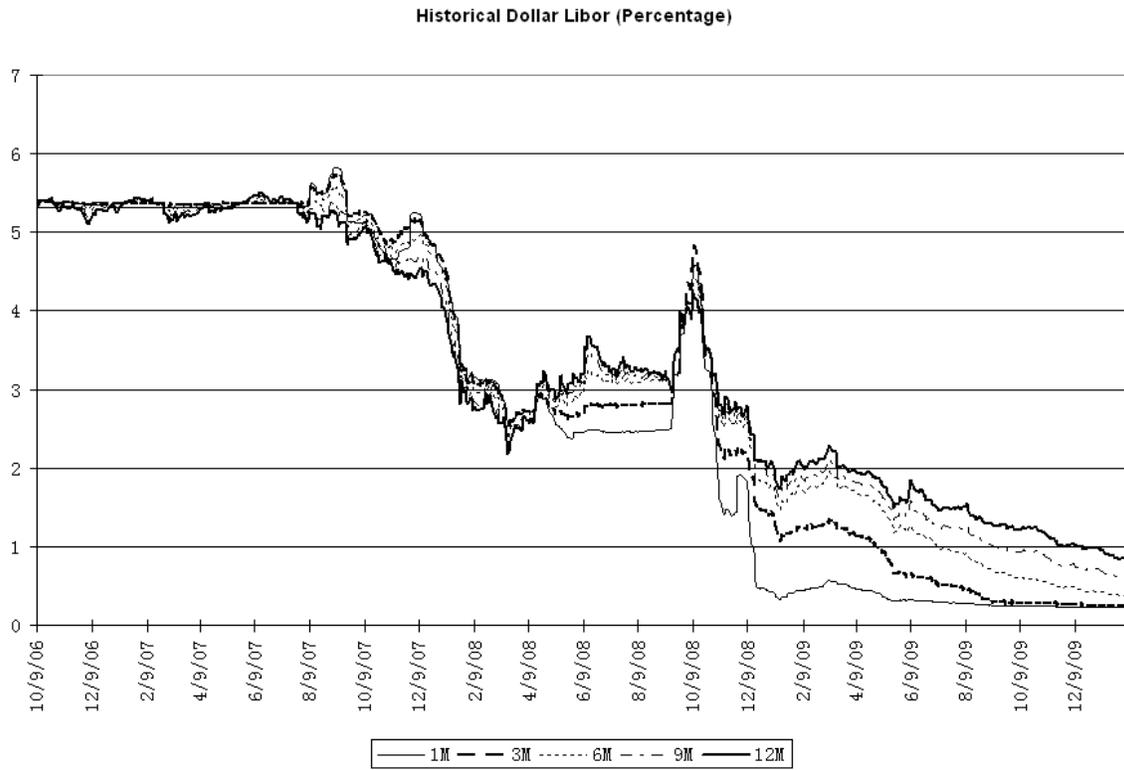


Figure 6:

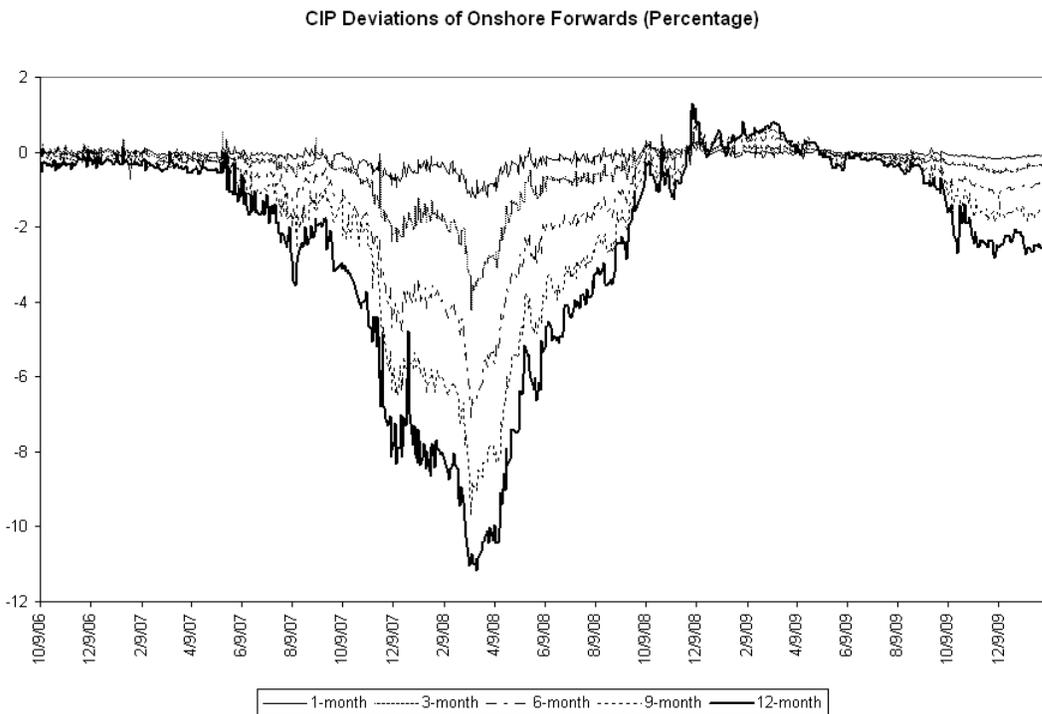


Figure 7:

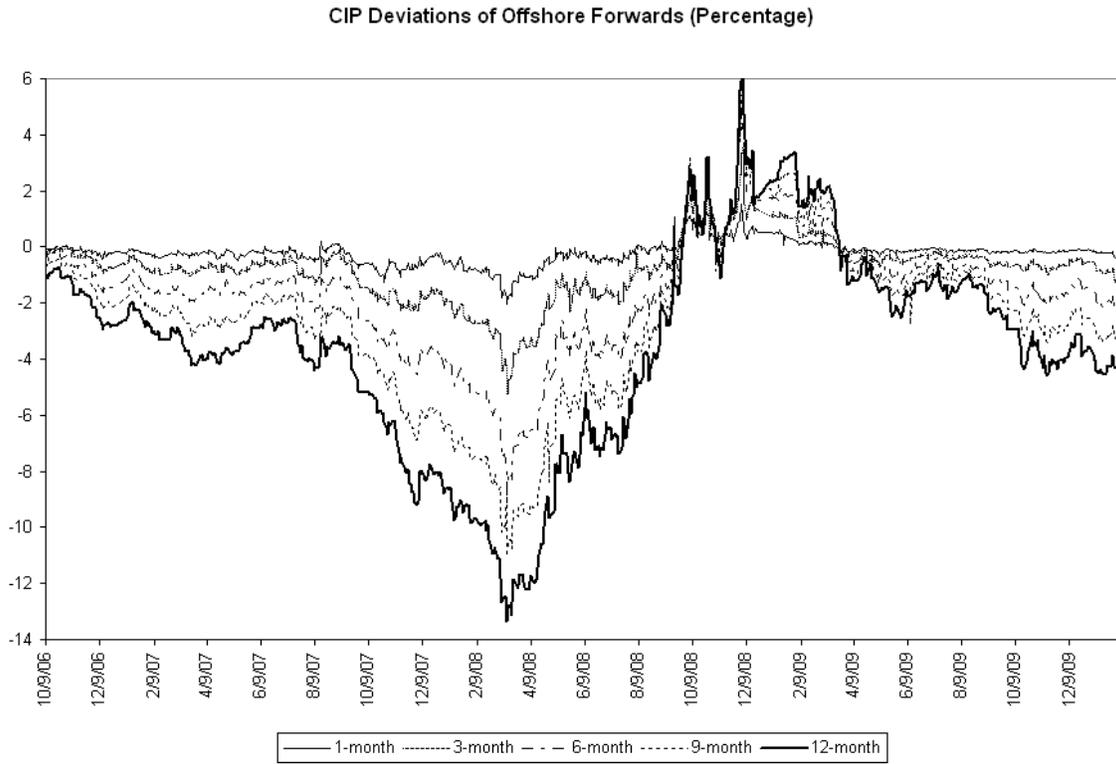
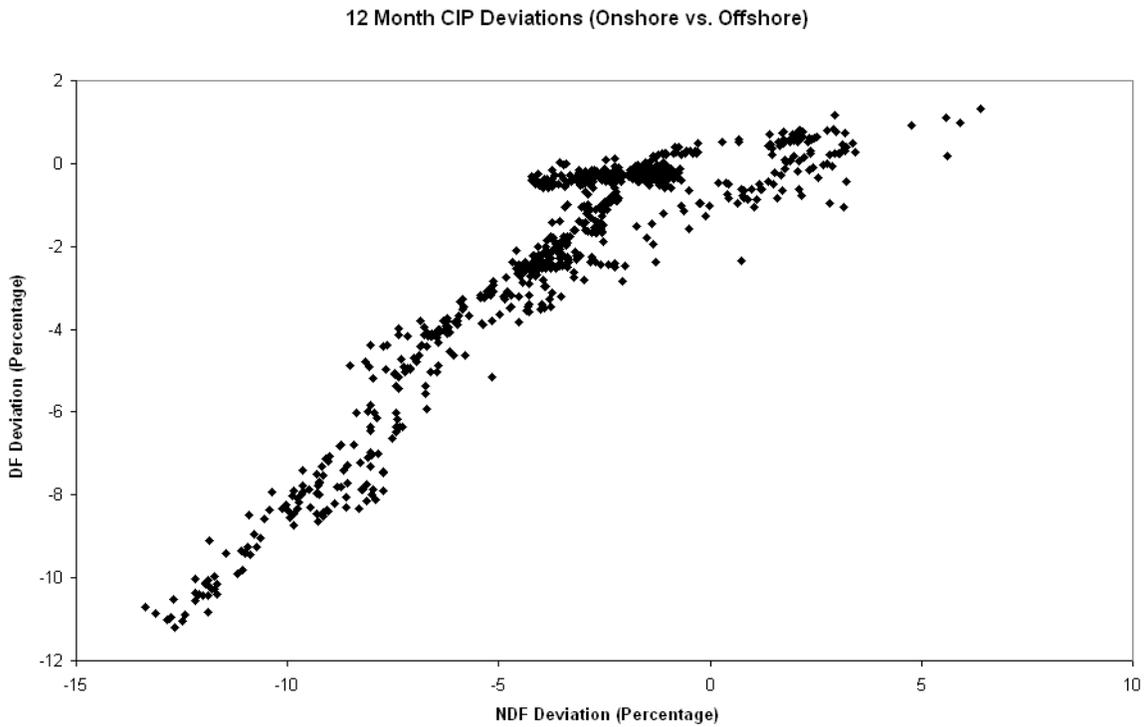


Figure 8:



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