Convertibility Restriction 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 primarily 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. Consequently, the level of conversion restriction should increase with 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 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.

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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 transaction volume data of this interbank 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 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 for the onshore interbank 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. 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 instead of just one in order to have a more comprehensive understanding of the dollar-Yuan forward markets.

Other than the amount of money involved in the forward markets, another important reason that economist 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 also have real impacts on international trade activities. This is because that forward contracts are one of the main tools importer and exporters use to hedge exchange rate uncertainties, which hinges on the proper functioning of forward markets. In light of the above motivations, 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). 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 offshore 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).[2] 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.[3] In addition, although CIP-violations in both

[2] The pairings of deliverable contracts to the onshore market and non-deliverable contracts to the offshore market is not arbitrary but due to the fact that deliverable contracts are only traded onshore while the offshore markets only trade non-deliverable contracts. The type of contracts traded in each forward market, along with other institutional details, will be elaborated in Section 2.

[3] 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

markets do exhibit a high degree of positive correlation, it is not immediately obvious if violation in one market always imply violation in the other. From Figure 1, one can see that prior to May 2007, CIP-violations between the two markets do not appear to be highly correlated. However, from May 2007 onward, the correlation between CIP violations of the two markets clearly increased. This paper argues that offshore CIP violation is a necessary but insufficient condition for onshore CIP violation, and whether the two markets exhibits CIP violations simultaneously primarily depends on the level of conversion restriction that Chinese foreign exchange authorities impose on the spot market.

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.

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

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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.

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. Of course, I am not ruling out the possibility that shortly after the Lehman bankruptcy, reason(s) that caused CIP deviations in the well-established markets might also explain the reversal of CIP-deviation direction in the Chinese markets. However, this is not the focus of this particular paper and will be reserved for another time. The focus of this paper is on the much greater CIP deviations in the Chinese market prior to Lehman bankruptcy.

For the offshore dollar-RMB NDF market, I am not the first to document CIP violations. In fact, CIP deviations in the offshore 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. However, this particular reason is no longer satisfying because certain participants have access and indeed participate heavily in both onshore and offshore markets during the sample period under investigation in this paper. 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 forward market. Wang (2010) hypothesizes that CIP deviations in the onshore market prior to Lehman bankruptcy 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 should be determined, and how exactly conversion restrictions influence forward pricing. This paper attempts to address these short comings.

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 their need to complete such transaction originates from current account activities. If the spot transaction in question originates from capital account activities, then the parties have to show that this particular capital account transaction is in line with capital control policies. In particular, any conversion transaction originating from capital inflow attempting to take 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 capital inflow to SAFE and consequently faces a strictly positive probability of 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 of-the-shelve 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.[4] 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 polices that denied transactions in the spot market. Hence, models developed to study the German experience cannot be transferred to study the Chinese experience.

Frenkel and Levich (1975 and 1977) argued that in the presence of transaction cost, there exists a "neutral" band around the CIP-implied forward price in which actual forward contract can be priced without generating arbitraging opportunities. Although one can argue that conversion restrictions in the spot market can be viewed as an increase in transaction cost in the spot market, such interpretation only generate a range of no-arbitrage-inducing forward prices but cannot explain the movement in the magnitude of CIP-violation. 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

[4] Conditional on the banks in comparison have similar credit risk

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 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 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 should decrease with export or import volumes depending on the direction of capital flow. 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. Empirical results are consistent with the model predictions.

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 is data description.

Section 5 presents 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 Offshore Retail Dollar-Yuan Forward Market

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 offshore dollar-yuan forward markets: Hong Kong and Singapore. The Singapore market dates back to December 1998 while the Hong Kong retail market did not pick up until October 2005.[5] 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 non-deliverable forward contracts of Singapore, forward maturity and price for the contracts offered in Hong Kong are standardized rather than

[5] 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)

individually negotiated between offering banks and investors. At the time of introduction of such retail forward contracts, Hong Kong Monetary Authority designated sixteen banks to offer this service.[6]

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

[6] 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 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.

savings account, current account or RMB saving account will be considered as settlement account after currency conversion.

The Hong Kong market is purely a retail market in the sense that the market making banks do not enter into forward contracts with each other. Instead, contracts are only traded between a bank and its customers. In addition, customers do not face the same interest rates as the banks do, nor do they have access to the onshore interbank forward market. In addition, customers do not enter into contract with each other in this market and can only trade with a bank. Given that the banks have access to the onshore interbank forward market, the banks can realize a profit by arbitraging the price difference between the interbank and retail markets.

2.2 Interbank 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 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.[7] 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,[8] hence no after hour trading is allowed. Currently, the products being traded on CFETS include spot trading, deliverable forward contracts between RMB and

[7] The 18 cities are Guangzhou, Shenzhen, Tianjin, Jinan, Dalian, Nanjing, Xiamen, Qingdao, Wuhan, Chongqing, Chengdu, Zhuhai, Shantou, Fuzhou, Ningbo, Xian, Shenyang, and Haiko
[8] 9:30-15:30 Monday through Friday with the exception of holidays

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).[9] Out of the existing members, there are 16 that serve as primary market makers in both spot and forward markets.[10] Out of these 16 members, 6 are also market makers in the retail forward market described in the subsection above.[11]

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 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

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[9] As of 11/24/2009

[10] 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.

[11] Bank of China, Citibank, HSBC, Industrial & Commercial Bank of China, Standard Chartered Bank, Royal Bank of Scotland.

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. Hence, once the spot price of the day has been announced, Chinese foreign exchange regulatory authorities need to make two decisions: How much dollar to buy (or sell) and how many transactions to deny.

The Chinese monetary authorities are quite active in their attempt to guide market expectation of future spot rate and use the official announced spot rate as a tool to signal the market on what future spot rates will be announced. Consequently, the market uses this signal along with other available information to form expectation of future spot rate. However, this government-announced signal is not the only input of the market's expectation formation. For example, although the Chinese government might want to convince the market that it will keep the spot rate flat into the indefinite future by announcing a spot rate equal to that of yesterday and by making official statements on their commitment to maintain a stable exchange rate, the market might still anticipate movements in the spot rate in the near future due to other available information such as U.S. exerting pressure on China to appreciate the RMB or the U.S. dollar is appreciating against other major currencies. In the next section I argue theoretically that these anticipated movements in spot rate are reflected by the offshore forward rates.

Forward contracts in this market are deliverable contracts with standardized maturities.[12] Yet, a forward contract in the interbank market can also be net settled, meaning that it is indeed possible to trade non-deliverable forwards in the onshore market

[12] 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.

as well. The actual breakdown between deliverable forwards and non-deliverable forwards in the onshore market is unavailable. Nonetheless, given that deliverable contracts are unique to the onshore market and not traded in the offshore market, I use the term deliverable forward market to describe the onshore market in this paper. The settlement rate is defined as the closing spot rate two days prior to 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 the onshore interbank forward contracts is to allow banks to provide better hedging instruments to their customers (CMPR 2007Q2)[13]. Hence, it appears that the intended objective of the interbank forward market is to allow banks to cover any net forward positions they have accumulated in the retail market with their customers. Consequently, it also allows banks that participate in both markets to profit from the pricing differences between the two markets. One might wonder why is not any difference in pricing between the two markets driven to zero by competitive forces, but bare in mind that the number of banks allowed to function as market makers in the retail

[13] "CMPR" is short for China Monetary Policy Report, see reference for further details

forward market are limited to 16 and banks are not allowed to trade with each other in the retail market.

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 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, interbank 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.[14] 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.

[14] 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.

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

3.1 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 (interbank) 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 dollar and RMB ($i_{\$,t}$ and $i_{RMB,t}$ respectively) as exogenously given.

The spot market functions as the following. Every period, the central bank announces an exogenously given spot price (S_t). Everyone 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 through a combination of two ways. The first is to transact with any unmatched orders by selling or buying dollar in the spot market. 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 it wants to deny and other types it wants to approve, but it has difficulties differentiating these transactions because it does not have perfect information.

Assume that every order the central bank receives belongs to one (and only one) of the following three groups: transactions originating from current account activities and capital account activities allowed by the Chinese government (*L*), transactions originating from capital account activities not allowed by the Chinese government (*I*), and transactions associated with forward covering (*C*). *L* and *C* are transactions that the central bank does not want to disturb while *I* are transactions that central bank wants to block. 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 a fraction or all of his dollar revenue into RMB so he can pay for his RMB liabilities. An example of an *I* transaction is a dollar selling order placed on behalf of a speculator who wants to convert dollar 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 dollar in period t (H_t) in the spot market is equal to the difference between the quantities of dollar selling orders and the dollar buying orders, which can be described by the following equation.

$$H_t = L_t^S + I_t^S + C_t^S - \left(L_t^B + I_t^B + C_t^B\right).$$ [15]

Since the *L* transactions are assumed to result from current account activities, and China's current account activities are predominantly trade related, the model makes the

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

simplifying assumption that quantities of *L* transactions are increasing functions of trading volumes: $L_t^S = \left(X_t\right)^a, a \in [0,1]$ where X_t is the volume of China's export; $L_t^B = \left(M_t\right)^b, b \in [0,1]$ where M_t is the volume of China's import.

Given that *I* transactions are associated with speculative capital flows attempting to take 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 next period. In particular, assume that $I_t^S = \begin{cases} f\left(\dfrac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}\right), if \dfrac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > 1 \\ 0, o.w. \end{cases}$

and $I_t^B = \begin{cases} g\left(\dfrac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}\right), if \dfrac{E_t\left[S_{t+1}\right]}{F_{CIP,t}} > 1 \\ 0, o.w. \end{cases}$, where $F_{CIP,t} \equiv S_t \dfrac{1+i_{RMB,t}}{1+i_{\$,t}}$. For now, the model assumes that functions *f* and *g* are increasing functions but do not impose additional structures on them. In Cheung & Qian (2010), the authors argue 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 my model. I prove in the next subsection that offshore forward rate is equal to $E_t[S_{t+1}]$; hence, the assumption above that the quantity of *I* transactions depends on UIP deviations is consistent with the empirical findings presented in Cheung & Qian (2010).

The model assumes that I_t^S and I_t^B cannot both be strictly positive simultaneously. Given the goal of the central bank is to block I_t^S or I_t^B while approve L_t^S, L_t^B, C_t^S, and C_t^B, it only needs to apply conversion restriction on one direction for any particular period.

Hence, the central bank applies conversion restriction on the dollar selling (buying) orders if and only if $\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > (<) 1$.

Every period, the central bank first attempts to identify the transactions that it thinks 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.[16] More concretely, if we let $\hat{T}$ to be the central bank's classification of a particular transaction and let T be its true classification, then $p\left(\hat{T}=I \middle| T=I\right)=p\left(\hat{T}=I \middle| T=C\right)=1$ 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 not without mistake. In particular, assume that $p\left(\hat{T}=I \middle| T=L\right)=\frac{\left(\alpha_t\right)^{n-1}}{n}$, where *n* is an exogenous precision parameter greater or equal to 2.

It might appear counterintuitive to assume that the central bank's mistake function in identifying *L* transactions depends on the fraction of $\hat{T}=I$ transactions that it wants to deny. 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 to increase the list of potential suspects. The other channel is by increasing the fraction of denial (α_t). Consequently, a tightening of conversion restriction by the central bank would be

[16] This assumption derives from the fact that current SAFE guidelines does not appear to state explicitly whether forward covering spot transactions should be approved or not, probably because SAFE has no way of identifying them. Nonetheless, one would imagine that spot transactions associated with forward covering should be approved.

reflected in both an increase in α_t and an increase in $p\left(\hat{T}=I \middle| T=L\right)$. Hence, it is conceivable that $p\left(\hat{T}=I \middle| T=L\right)$ is an increasing and convex function of α_t. The assumption that this particular function takes the form of $\frac{(\alpha_t)^{n-1}}{n}$ is a simplifying assumption that makes algebra 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 α_t.

To summarize, α_t measures the level of convertibility restriction the central bank places on the spot market in period t. Essentially, a convertibility restriction of α_t denies α_t fraction of illegitimate transactions, but also denies α_t fraction of covering transactions and $\frac{(\alpha_t)^{n}}{n}$ of legitimate transactions of the same direction, and perhaps even influencing the amount of transaction requests. Consequently, imposing conversion restriction has the benefit of curbing and perhaps discouraging illegitimate transactions, but also has the costs of mistakenly denying legitimate transactions and disturbing forward covering transactions. Naturally, the determination of an optimal level of conversion restriction should originate from an objective function that balances its benefits and costs. I address the determination of conversion restriction levels later in this section. But first, I address the impact of any given level of α_t on forward rates in the next subsection.

3.2 Forward Pricing under Conversion Restriction

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 interbank 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. In addition, there are 16 retail banks and additional entries by other banks are not allowed.

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.

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 for them to 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. From the Section 2, it has been established that for retail customers to participate in the retail forward market, they have to be account holders at one of the retail banks. Consequently, it is probably costly to them to switch banks. Hence, I assume that the retail customers do not switch banks solely for the purpose of locating a better rate on a forward contract as long as their expected profit when trading at $F_{ND,t}$ is greater than a negative constant. An immediate implication of this assumption is when offered a forward rate such that the expected loss from the forward transaction is zero, then a retail customer does not switch to a different retail bank even if that other bank offers a slightly more attractive forward rate.

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 central bank-imposed convertibility restriction impacts the forward markets because transactions associated with internally covering a forward appear to the central bank as illegitimate transactions and hence face probability α_t of being denied. Consequently conversion restriction translates into an uncertainty for hedging forward positions. 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 legitimate transaction to the central bank.[17]

Proposition 1: Interbank forward pricing is described by Equation (2)

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

Proof:

First consider the case of $F_{CIP,t} > E_t\left[S_{t+1}\right]$, which means that conversion restriction is imposed on dollar selling orders in the spot market. For the party that buys dollar 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 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) $$F_{D,t} \leq (1-\alpha_t)F_{CIP,t} + \alpha_t E_t[S_{t+1}]$$

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.

[17] This assumption derives from the institutional detail that the forward trader can present the forward contract on maturity date to the central bank, which will serve as credible evidence that his requested spot transaction is associated with covering a forward position and hence be approved. Notice that the practice of presenting a forward contract to the central bank in period t is not a credible signal that the requested spot transaction is legitimate because the trader can enter into a forward contract of the opposite transaction immediately after his spot transaction is approved.

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. Notice that the dollar forward seller is selling his dollar at a discount relative to $F_{CIP,t}$, but he is willing to enter such a trade because $F_{D,t} > E_t[S_{t+1}]$, which means his expected profit is strictly positive if he does not internally cover his forward position.

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

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

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

The dollar buyer wants to have $F_{D,t}$ as low as possible, but there will simply be no seller if (1.2) 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 interbank 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 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:

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

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

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.

Proposition 3: (2) $F_{ND,t} = E_t[S_{t+1}]$.

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

According to Proposition 3, the offshore retail forward rates would violate CIP as long as $F_{CIP,t} \neq E_t[S_{t+1}]$ and are independent of α_t. Notice that the retail market makers (i.e. the retail banks) can realize strictly positive profit 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 not only protected from competition of new entrants, but also from each other to a certain extent, which allows them to make strictly positive profit in equilibrium.

3.3 Optimal Conversion Restriction Policy

Before talking about the determination of conversion restriction, I address the possibility of changes in conversion restriction level influencing the amount of spot transaction requests initially brought up in Section 3.1, starting with the *I* transactions. 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 spot requests because they have no chance of being approved anyway. To incorporate this possibility, the model further assumes that *I* transactions, in addition to being functions of UIP deviations, are also decreasing functions of α_t. Consequently, $I_t^S = \begin{cases} f\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}, \alpha_t\right), if \ \frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > 1 \\ 0, o.w. \end{cases}$

and $I_t^B = \begin{cases} g\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}, \alpha_t\right), if \ \frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}} > 1 \\ 0, o.w. \end{cases}$, where $f_2, g_2 \le 0$, $f_{22}, g_{22} \ge 0$ and $f_{12}, g_{12} \le 0$.[19]

The assumption that the second derivatives are positive reflects the belief that the influence of conversion restriction on illegitimate transactions becomes more pronounced as the level increases. The assumption that the cross derivatives are negative reflects the notion that as conversion restriction gets tighter, the influence of UIP deviations on the amount of *I* transactions decreases.

The model assumes that the amount of *L* transactions is independent of α_t. This assumption might appear less defendable at first because if a Chinese exporter cannot convert his dollar revenue into RMB at all, he would most likely stop being an exporter altogether. Hence, although international trade (and hence spot transactions associated with it) should decrease with α_t at perhaps a very dramatic rate when the denial probability for legitimate transactions reaches beyond a certain level, it is less likely to be sensitive to α_t for more moderate levels of denial probability, in which case the exporter would conduct his business as usual and consequently does not alter his legitimate transaction requests.[20]

[19] The subscript reflects the variable with respect to which the partial derivative is taken.
[20] Of course, the possibility of denial might induce the exporter to alter his saving behavior in RMB. In case his request is denied in a given period, his extra RMB savings can allow him to remain in business. This possibility is purely a guess on my part and the exact influence of denial probability on an exporter's saving/investment behavior is beyond the scope of this paper.

So the question boils down to whether the denial probability on legitimate transactions falls within the sensitive range. When $\alpha_t = 1$ in my model, the central bank will deny all the transactions they believe to be illegitimate but not all transactions. In fact, there is an upper bound on the fraction of legitimate transactions the central bank can deny, which is determined by the exogenous precision parameter *n*. Hence, although legitimate transaction requests would decrease with the level of convertibility restriction in the extreme case example described above, they are probably insensitive to α_t in China's case. Given that China has full current account convertibility according the IMF, which means that the denial probability faced by legitimate transactions must be low for all levels of α_t (i.e., *n* is high enough),[21] I make the simplifying assumption that trade activities and hence the amount of legitimate transactions are independent of α_t.

Finally, the model also assumes that the amount of forward covering transaction is independent of α_t. The amount and direction of spot transactions a forward trader wants to request depends on the amount of forward contracts he has, and the amount of forward contract 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 underlying import and export volumes. Given that I have assumed that trade volumes are independent of α_t in China's case, to remain consistent I am assuming that forward covering transactions are also independent of α_t.

[21] Although the model treats the precision parameter *n* as exogenously given, it is more likely the case that *n* is ensured to be high enough by conscious efforts of the central bank such that RMB remains current-account fully convertible. My model abstracts away 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 should the level of conversion restriction be determined when *n* is high enough but fixed.

Consequently, the quantity of net dollar supplied in the spot market for each period is described by Equation (3)

$$(3)\, H_t = \begin{cases} \left(1-\frac{(\alpha_t)^n}{n}\right)(X_t)^a - (M_t)^b + (1-\alpha_t)\left[f\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}, \alpha_t\right) + C_t^S \right] - C_t^B, if \frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} > 1 \\ (X_t)^a - \left(1-\frac{(\alpha_t)^n}{n}\right)(M_t)^b - (1-\alpha_t)\left[g\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}}, \alpha_t\right) + C_t^B \right] + C_t^S, o.w. \end{cases}$$

With Equation (3) in hand, we now shift our focus to the determination process of conversion restriction. Given that the goal of imposing conversion restriction is to block and discourage illegitimate 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, central bank should impose conversion restrictions on dollar selling (buying) transactions when $F_{CIP,t} > (<) E_t\left[S_{t+1}\right]$ and not impose any restrictions when $F_{CIP,t} = E_t\left[S_{t+1}\right]$.

From here, there are two possible ways that the central bank can determine α_t and H_t. One way is to establish a level of H_t first, and then determine α_t according to Equation (3). Note that in this method, the model allows the level of H_t to be exogenously given. The second is to determine α_t first while taking into account the fact that any positive level of α_t incurs the cost of disturbing legitimate transactions, and then endogenously determine H_t according to Equation (3).

Under the first case, α_t is pinned down by H_t and the cost of α_t disturbing legitimate transactions does not enter into the determination process. In the second method, the determination of α_t can and should take into account the cost associated with incorrectly denying legitimate transactions. Furthermore, the determination process of α_t should not incorporate level of H_t. Instead, H_t would be endogenously pinned down by α_t according to Equation (3). In short, the second method does not allow H_t to be exogenously determined. Given that the officially stated goal of imposing spot market conversion restrictions is to block and discourage illegitimate transactions rather than to achieve a certain level of open market intervention by the PBoC, the Chinese authorities *should* utilize the second method in order to stay consistent with the stated objective. Consequently, the objective function of the central bank should be the following:

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

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

where $\lambda > 0$ is that the cost that the central bank attaches to its mistake of incorrectly denying legitimate transactions.[22] Notice that the first component of the objective function represents the false negatives (i.e. mistakenly approving *I* transactions) and the second component represents false positives (i.e. mistakenly blocking *L* transactions).[23]

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

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[22] The exact magnitude of λ and what is the optimal magnitude of λ are important questions to investigate as well, but the current paper does not focus on these questions.

[23] Given that *C* and *I* transactions cannot be differentiated at all by the central bank, the cost of mistakenly denying *C* transactions are 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.

$$(4.1) \quad f\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]},\alpha_t\right)=\left(1-\alpha_t\right) f_2\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]},\alpha_t\right)+\lambda\left(\alpha_t\right)^{n-1}\left(X_t\right)^a, if\ \frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}>1$$

$$(4.2) \quad g\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}},\alpha_t\right)=\left(1-\alpha_t\right) g_2\left(\frac{E_t\left[S_{t+1}\right]}{F_{CIP,t}},\alpha_t\right)+\left(\alpha_t\right)^{n-1}\lambda\left(M_t\right)^a, o.w.$$

Proposition 4: The level of conversion restriction should be increasing with absolute value of UIP deviation and decreasing with trade volumes.

Proof:

Start with Equation (4.1) and assume that $\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}$ has increased. This will lead to an increase to the LHS and decrease in the RHS because $f_1>0$ and $f_{12}\le 0$. Consequently, α_t needs to change in a direction to bring the expression back to equality. The direction is up. To see this, notice that an increase in α_t would lower the LHS because $f_2\le 0$. The fact that an increase in α_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 α_t, which is expressed explicitly below.

$$(4.3) \quad \left(1-\alpha_t\right) f_{22}\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]},\alpha_t\right)-f_2\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]},\alpha_t\right)+\lambda\left(n-1\right)\left(\alpha_t\right)^{n-2}\left(X_t\right)^a$$

Notice that the first component of (4.3) is positive because $f_{22}\ge 0$, and the second component is a subtraction of a negative number and the third component is also positive. Consequently, (4.3) as a whole is positive, implying that the RHS of (4.1) is increasing in α_t. The argument using (4.2) is almost identical and hence skipped.

QED

3.4 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 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 (4.1) that α_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. If we combine this implication with Proposition 3, which states that offshore forwards are a measure of spot rate expectations, 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. Furthermore, it shows that CIP deviation in the offshore market is a necessary condition for onshore deviation in general, and this condition becomes a sufficient condition if the Chinese authorities impose convertibility restrictions in the spot market.

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 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 a regression.

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

Hence, conditional on the assumption that convertibility restriction 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 $\hat{\alpha}_{post} > \hat{\alpha}_{pre}$ if the hypothesis is correct.

Implication 4: In the model, the only variables that influence α_t are UIP deviations and trade volume. 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 how each should influence α_t directionally. Acknowledging the need for additional structure to have a structural regression, perhaps Regression (2) can serve as a reduced form to take to the data.

Regression (2) $$\ln\left(\alpha_t\right) = \beta_0 + \beta_1 \ln\left(X_t\right) + \beta_2 \ln\left(\frac{F_{CIP,t}}{F_{ND,t}}\right) + \varepsilon_t$$ [24]

In particular, Proposition 4 predicts $\beta_1 < 0$ and $\beta_2 > 0$. Unfortunately, there is no direct measure of α_t. Instead, we only have the relationship $F_{D,t} = (1-\alpha_t)F_{CIP,t} + \alpha_t F_{ND,t}$. Hence, a less direct way is utilized to examine the validity of the model:

1. Use a portion of the data to estimate β_1 and β_2, with the exact methodology to be described in detail in Section 5.

[24] The linear set up might not be as reduced as it might appear since whatever structural form the relationship might be, a log-linear approximation might be able to generate Regression (2).

2. Using $\hat{\beta}_1$ and $\hat{\beta}_2$ obtained from step 1, generate a sequence of $\hat{\alpha}_t$ for a different time interval using the law of motion $\ln(\alpha_t) = \ln(\alpha_{t-1}) + \beta_1 \Delta \ln\left(\frac{F_{CIP,t}}{E_t[S_{t+1}]}\right) + \beta_2 \Delta \ln(X_t)$.

3. Using the $\hat{\alpha}_t$ from step 2, predict the interbank CIP deviation and compare the sequence of predicted deviation to the actual CIP deviation.

4. Data Description

With respect to forward rates of both NDF and DF, I obtain daily observations from October 19, 2005[25] to February 5, 2010. The NDF rates are from Hong Kong NDF 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>

Finally, empirical implication 4 from the previous section requires trade data. Given that daily import/export volumes between China and U.S. are unavailable, monthly

[25] The first day DF was introduced in CFETS.

trade volumes are used instead and are depicted in Figure 8. The source is IMF Direction of Trade database.

<Insert Figure 8 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 $\lim_{n\to\infty} \frac{1}{n}\sum_{t=1}^{n}(F_{ND,t} - S_{t+1}) = 0$

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.[26] 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 reason to believe that offshore forward prices are unbiased predictors of 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

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

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 9 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 9 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

	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.

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

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

Table 4: Regression Results for Regression (1) by Forward Maturities

May 18, 2006-Feburary 5, 2010

	6M	**9M**	**12M**
$\hat{\beta}_1 \approx 1-\alpha$	0.3209 (0.0119)	0.2566 (0.0118)	0.2562 (0.0102)
$\hat{\beta}_2 \approx \alpha$	0.6782 (0.0121)	0.7438 (0.0121)	0.7434 (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 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 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, consistent with what Proposition 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 examined.

Implication 4: $\ln(\alpha_t) = \ln(\alpha_{t-1}) + \beta_1 \Delta \ln\left(\dfrac{F_{CIP,t}}{E_t\left[S_{t+1}\right]}\right) + \beta_2 \Delta \ln(X_t)$

From May 18, 2007 onward, one has reason to believe that SAFE started actively using conversion restrictions. The model predicts that $\beta_1 < 0$ and $\beta_2 > 0$. Intuitively, conversion restriction should tighten when illegitimate activities are rampant, but should be tuned down if there are a lot of legitimate transactions as well. If there is an explicit measure of conversion restriction, then β_1 and β_2 can be estimated by running regression (2). Unfortunately, there are no explicit measures of α_t available. Hence, one needs to be slightly more creative to estimate β_1 and β_2.

First, I isolate a period after May 18, 2007 in my sample period during which $F_{ND,t} < F_{CIP,t}$, which by Proposition 3 is equivalent to $E_t\left[S_{t+1}\right] < F_{CIP,t}$. I decided to focus on the time interval from May 21, 20007 to Aug 29, 2008. Although it is clear from Figure 1 that there are other time intervals this condition is satisfied, magnitudes of onshore CIP deviations were the greatest during this time interval. Furthermore, I want to avoid the few months after Lehman bankruptcy because there might be other factors causing CIP deviations in the onshore forward market.

The sample is once again divided into 2 roughly equal-length subintervals: May 21, 2007-Jan 31, 2008 and Feb 1, 2008-Aug 29, 2008. I use the first subinterval to estimate β_1 and β_2, then use the estimates to predict onshore CIP deviations during the second subinterval, and finally compare the predictions with the actual onshore CIP deviations.

The estimation method for β_1 and β_2 is the following:

$$\min_{\alpha_0,\beta_1,\beta_2} \sum_{t=0}^{n} \left[\left(F_{D,t} - \left(1-\alpha_t\right) F_{CIP,t} - \alpha_t F_{ND,t} \right)^2 \right]$$

Such that $\ln\left(\alpha_t\right) = \ln\left(\alpha_{t-1}\right) + \beta_1 \Delta \ln\left(\frac{F_{CIP,t}}{E_t\left[S_{t+1}\right]} \right) + \beta_2 \Delta \ln\left(X_t\right)$

Applying the above method to subinterval 1 using 12-month forward rates, $\hat{\beta}_1 = 7.8408$ and $\hat{\beta}_2 = -0.0072$. The signs of the estimators are consistent with model prediction. However, magnitude of $\hat{\beta}_2$ does not appear to be economically significant despite the fact that it has the correct sign. The interpretation is that a one percent increase in export volume is only associated with a 0.0072 percent decrease in conversion restriction. Given that $\alpha_t \in [0,1]$, such impact appears negligible. Consider the case of α_t =0.5, then a 0.0072 percent decrease from 0.5 is 0.499964, so the conversion restriction would barely decrease. Compare this to the fact that a one-percent increase in UID deviation is associated with 7.84 percent increase in α_t, it appears that conversion restriction during this period is not responsive enough to the volume of legitimate transactions.

Yet, there are also reasons that caution one from reading too much into the estimation results above. First, given the somewhat uniqueness of the estimation method, I have yet to settle on a defendable way to calculate the standard errors of my estimators. Hence, we do not know if the estimators are statistically significant. In addition, due to a lack of daily data on import/export volumes, monthly data is used instead. Consequently, changes in export volumes between consecutive days ($\Delta \ln(X_t)$) is a step function, which probably exerts a downward bias on the magnitude of $\hat{\beta}_2$ due to its lack of variability.

Despite of the weaknesses mentioned above, taking $\hat{\beta}_1 = 7.8408$ and $\hat{\beta}_2 = -0.0072$ at face value, we can then calculate a sequence of α_t and hence a sequence of predicted onshore CIP deviations for the second subinterval. Figure 10 depicts the predicted onshore CIP deviations and the actual onshore deviations.

<Insert Figure 10 here>

Although predicted CIP-deviation track the direction of movement of actual CIP-deviation fairly well, it does not coincide with actual data exactly. This is not surprising because my model only focuses on the impact of conversion restriction on CIP violations. In reality, there are probably other factors that contribute to the observed CIP violations as well, which is not in conflict with my hypothesis that the CIP violations observed in this sample period is primarily driven by conversion restrictions.

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 by blocking certain capital account transactions from happening. 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 level of export or import volume depending on the direction of capital flow. 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 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 significant. Finally, empirical evidence suggests that the behavior of conversion restrictions in China indeed increases with UIP deviation and decreases with export volume during periods of capital inflow, but further estimation should be performed.

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. Until such signal is discovered however, CIP-deviations in the onshore forward market would not go away.

Figures

Figure 1:

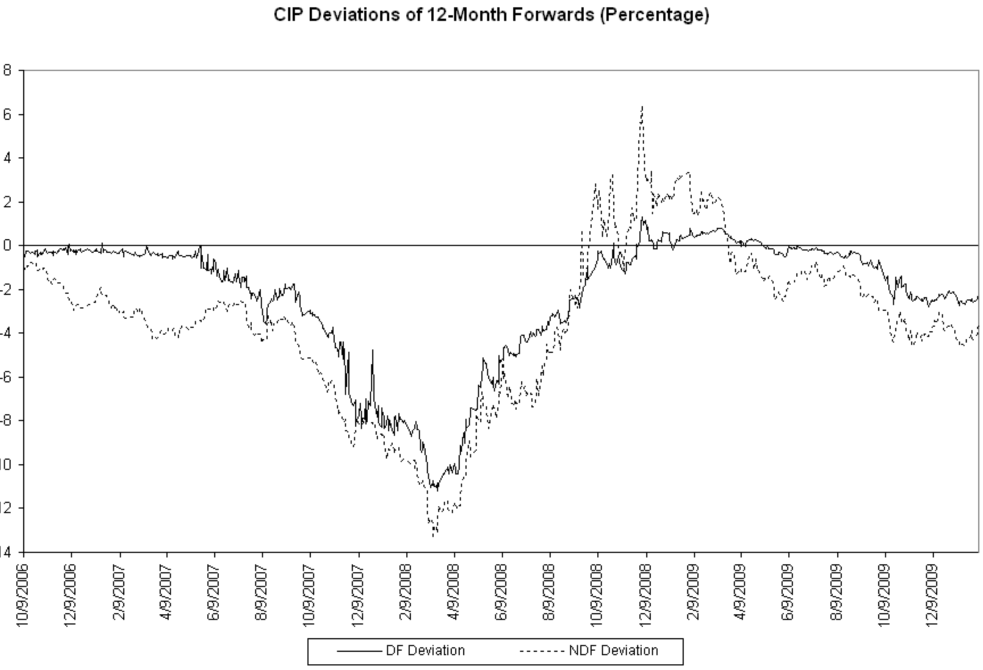


Figure 2:

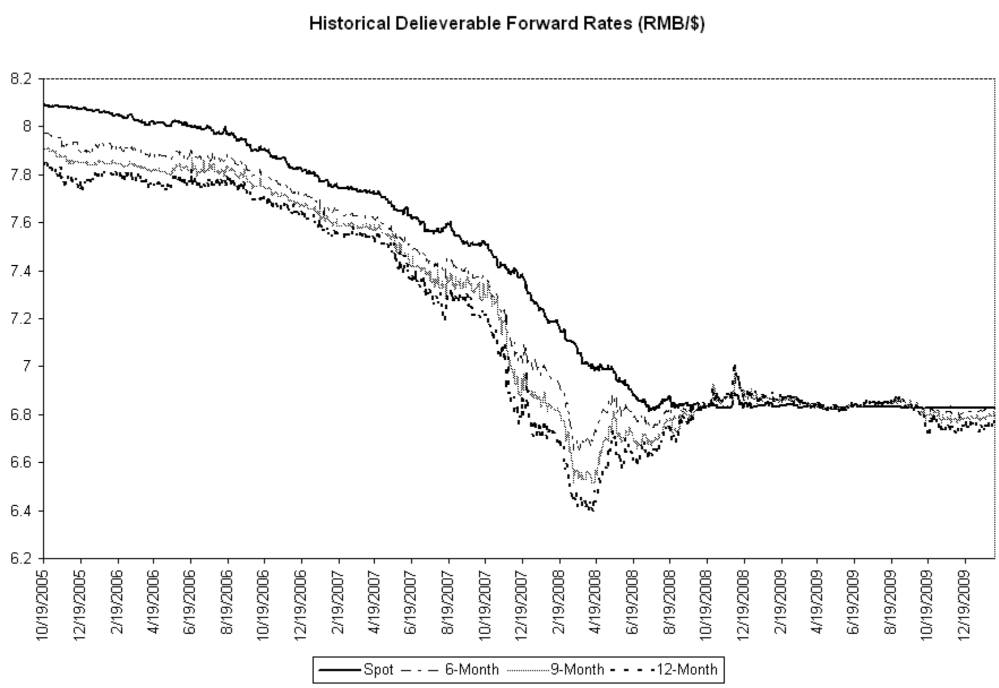


Figure 3:

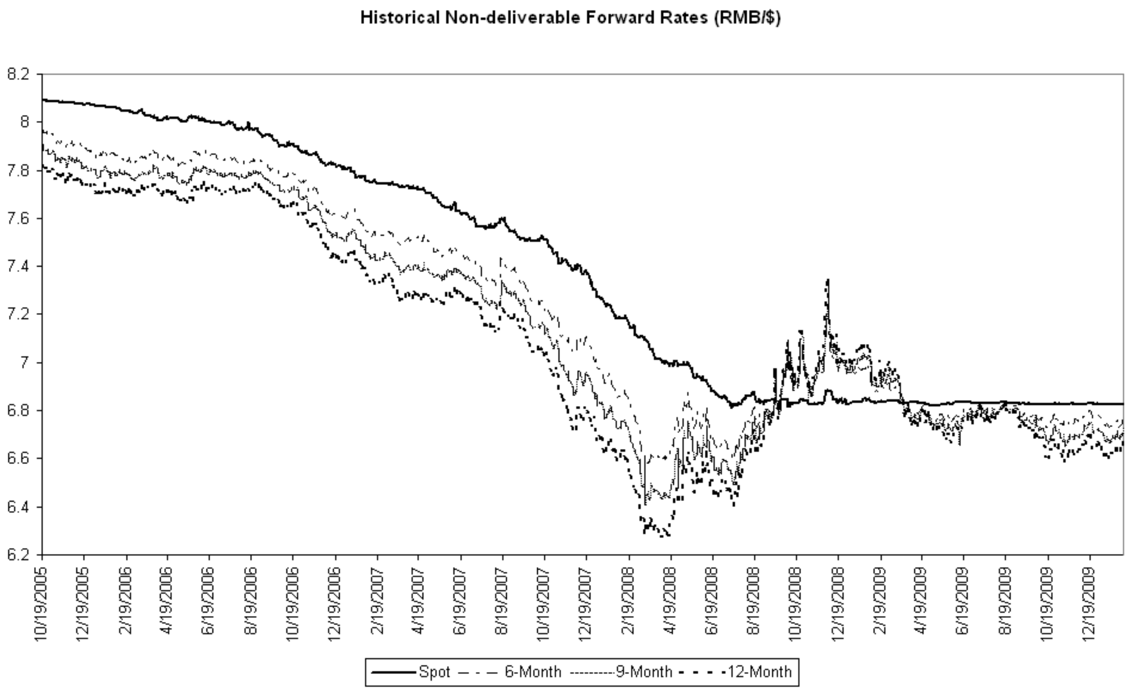


Figure 4:

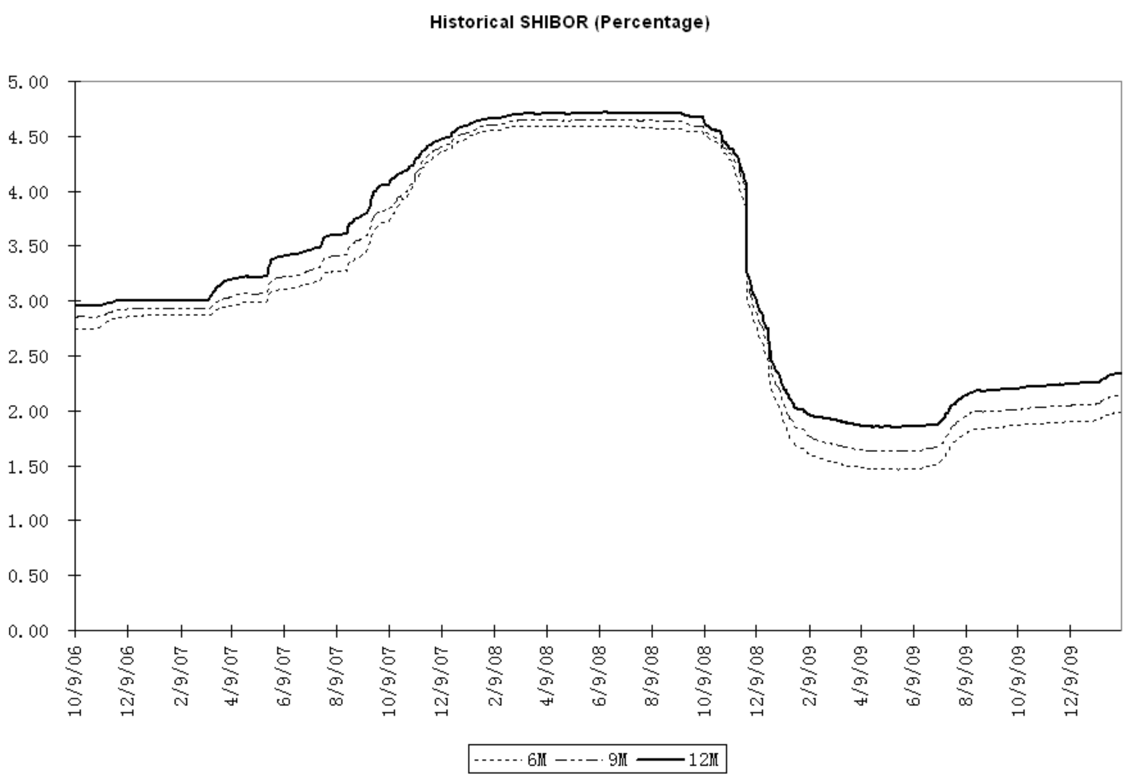


Figure 5:

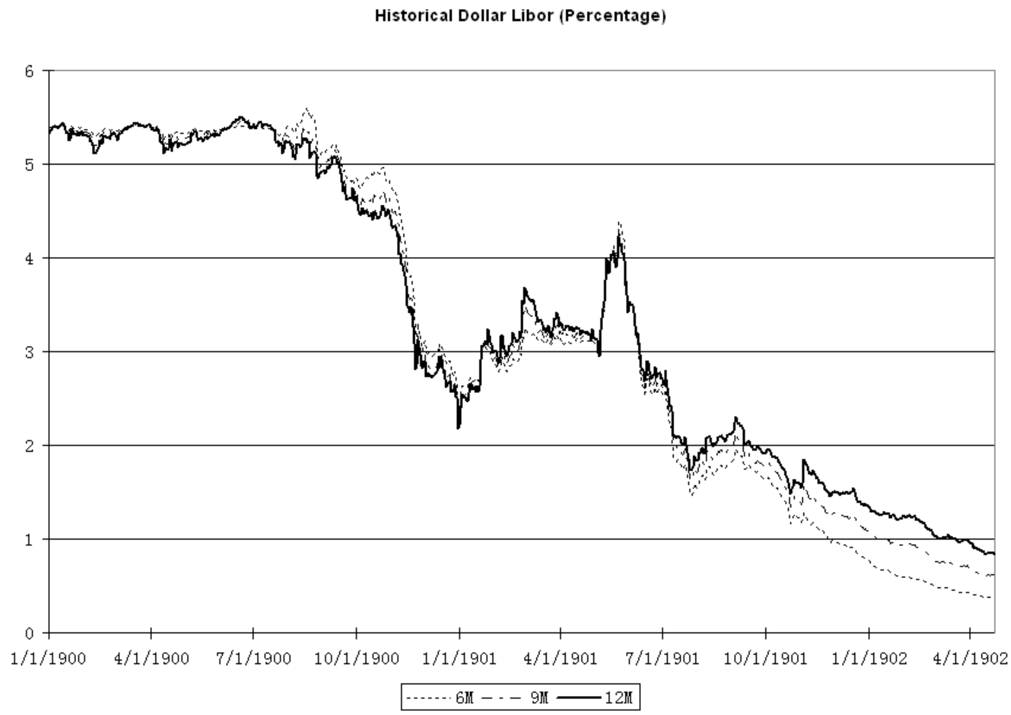


Figure 6:

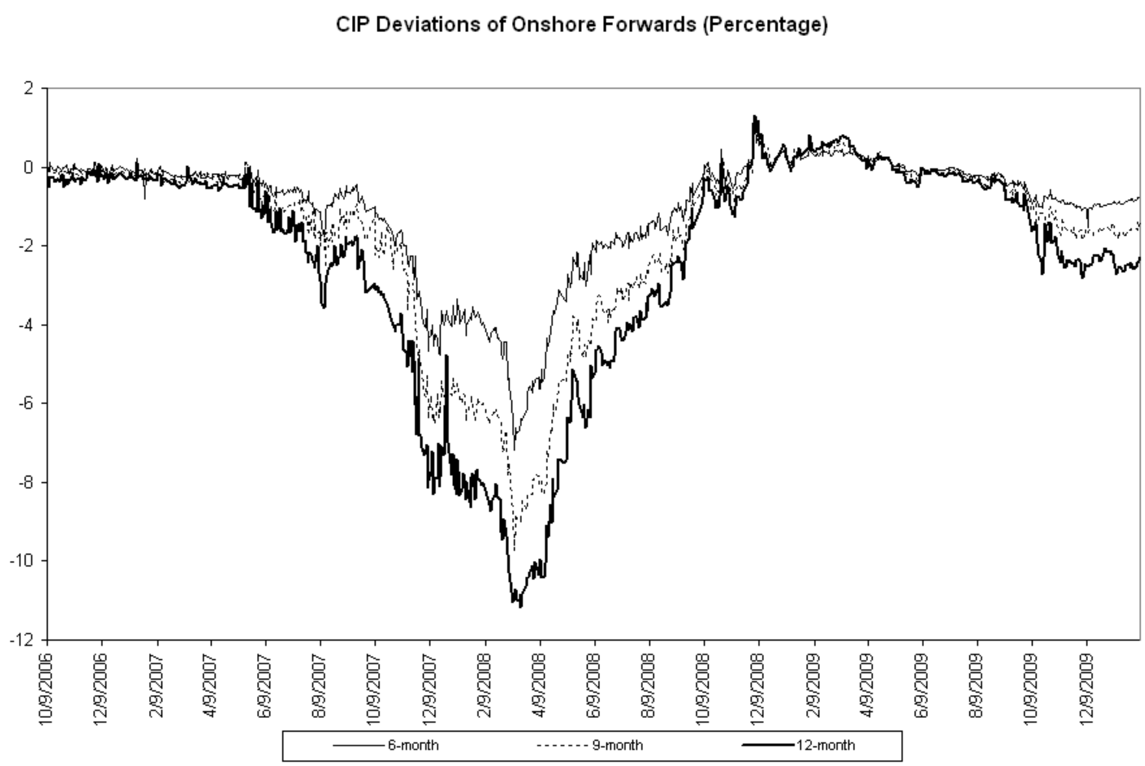


Figure 7:

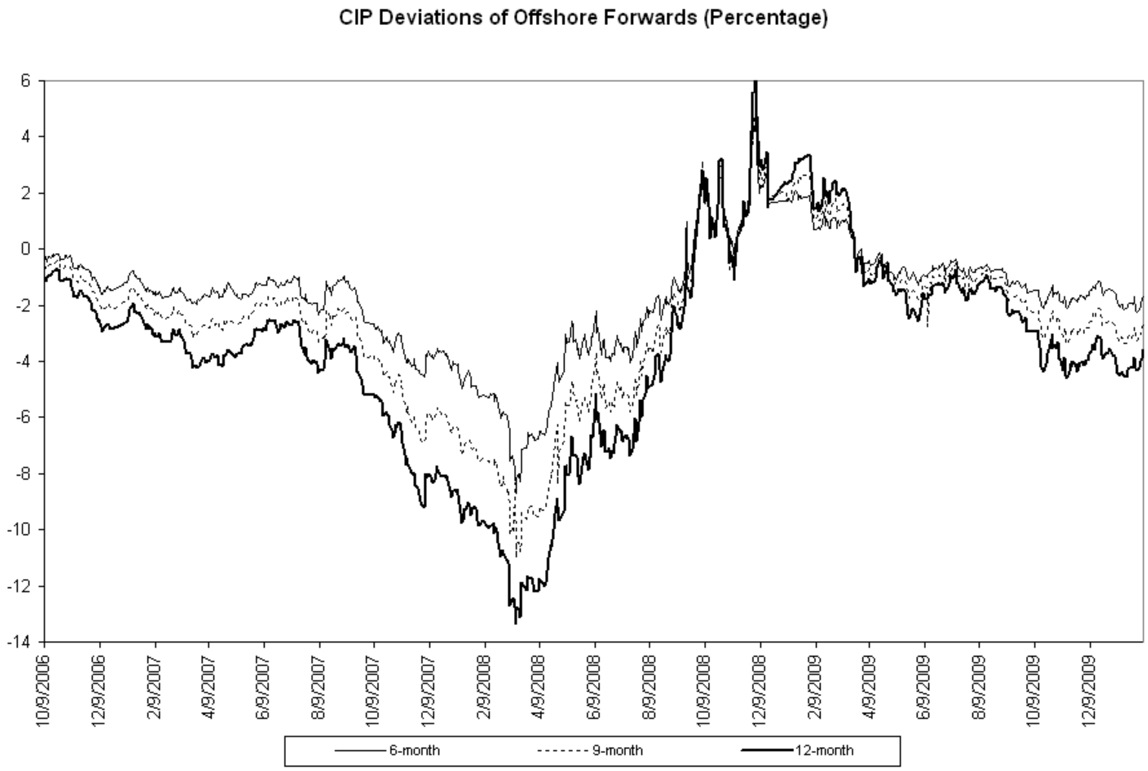


Figure 8:

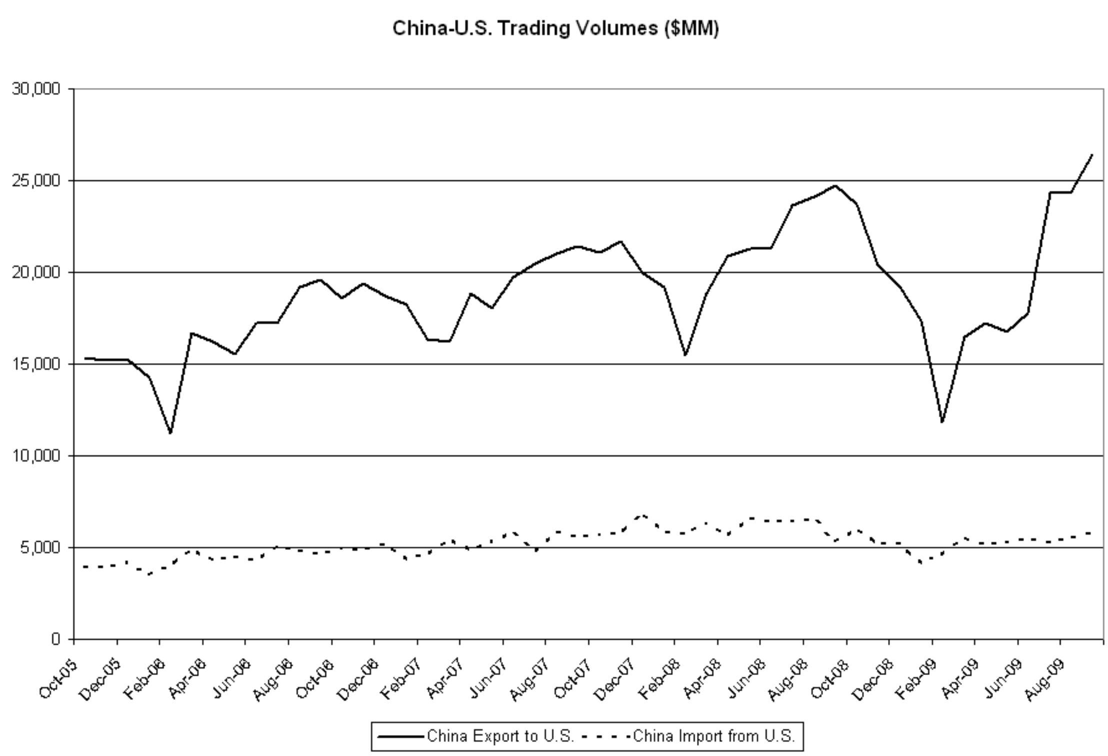


Figure 9:

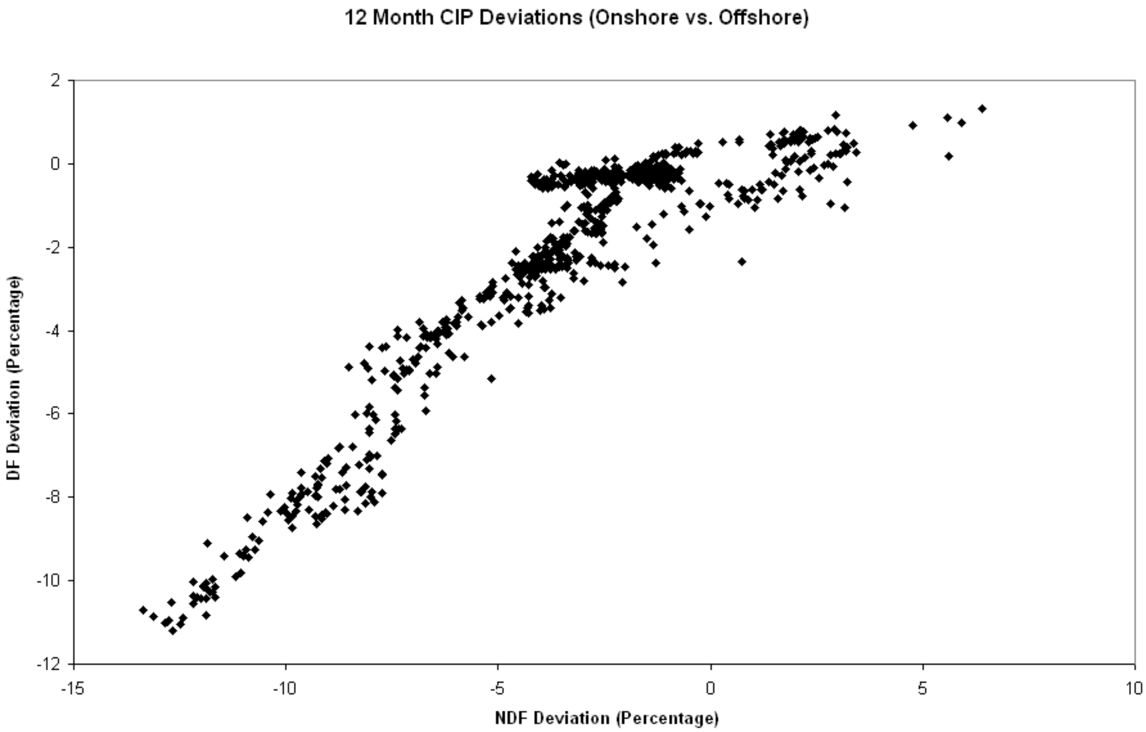
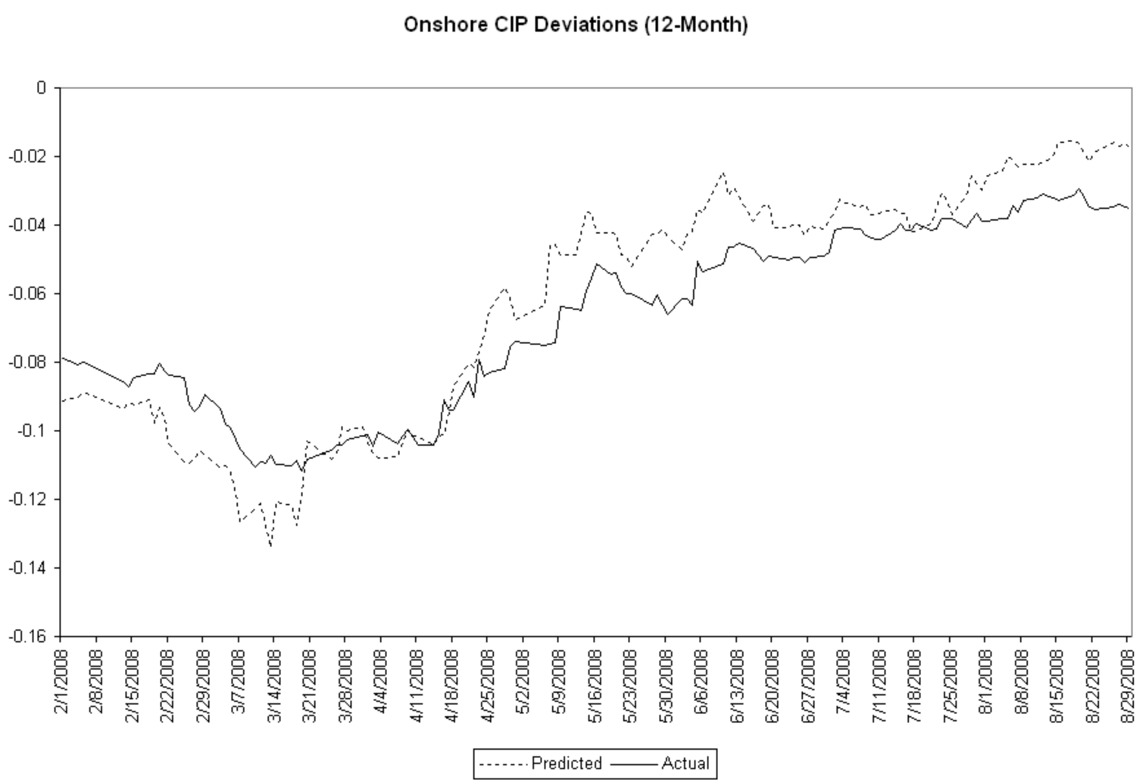


Figure 10:



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