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Development of the Renminbi Market in
Hong Kong SAR: Assessing Onshore-Offshore Market
Integration

R. Sean Craig, Changchun Hua, Philip Ng, and Raymond Yuen

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Asia and Pacific Department

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Assessing Onshore-Offshore Market Integration

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Abstract

Offshore use of the renminbi expanded rapidly in Hong Kong SAR as China sought to develop an international role for its currency while maintaining capital controls. This prompts two questions addressed in this paper: How far advanced is renminbi internationalization? And, what role does Chinese capital account liberalization play? The first is addressed by testing the extent of integration of offshore and onshore markets for the renminbi using a Threshold Autoregression (TAR) model and finds that there are substantial unexploited arbitrage opportunities. A VAR model is used to identify factors contributing to this limited market integration and finds that capital controls and shifts in global market sentiment explain much of the divergence in onshore and offshore renminbi exchange rates. To address the second question, the paper shows how capital account measures have been used to promote offshore use of the renminbi more actively in the wake of the global financial crisis, but that this was done asymmetrically with controls on inflows eased to a greater extent than on outflows. It concludes that a more balanced liberalization process will sustain progress in renminbi internationalization.

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I. INTRODUCTION

The development of an international role for the renminbi is tied to Chinese capital account liberalization. The selective easing of mainland capital controls expanded the range of cross border transactions denominated in renminbi and led to rapid growth in offshore renminbi deposits, bond issuance and lending in Hong Kong SAR. This growth leveled off in 2011 and has recently resumed at a more modest pace. These developments raise several questions. First, how far advanced is renminbi internationalization? This question can be addressed by assessing how effectively the offshore currency is functioning as a substitute for the onshore currency. Second, how has capital account liberalization supported the offshore use of the renminbi? And, third, how can this progress be sustained?

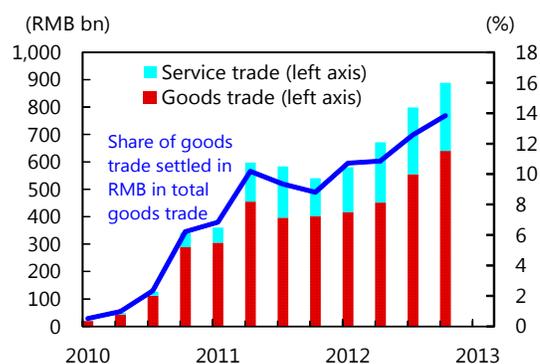
The next section examines the expansion in the offshore role of the renminbi, highlighting the uneven process across different uses of the offshore currency. Section III assesses progress in renminbi internationalization by estimating the integration of offshore and onshore renminbi markets. Specifically, a Threshold Autoregression (TAR) model is applied to daily data to test whether differential between the offshore exchange rate (the CNH) and the onshore exchange rate (the CNY) involves unexploited arbitrage opportunities and finds that this is the case. This likely reflects the limits on arbitrage from capital controls together with other factors. A VAR model is applied to monthly data to identify these factors and finds that shifts in global market sentiment plays a key role along with capital controls. Section IV examines how Chinese liberalization measures have promoted offshore use of the renminbi in Hong Kong SAR. Controls on capital inflows have been eased more than on outflows, suggesting that, going forward, more balanced liberalization measures would help sustain progress in renminbi internationalization.

II. DEVELOPMENT OF THE OFFSHORE RENMINBI MARKET

China is seeking to promote the international use of its currency while maintaining capital controls through the development of offshore markets for the renminbi. The offshore renminbi was established in 2003, with the creation of an offshore settlement infrastructure and personal renminbi banking services in Hong Kong SAR. Efforts to develop offshore renminbi financial products and services accelerated in 2009 as the global financial crisis exposed the fragilities of the dollar-based international financial system.

Promotion of an international role of the renminbi initially focused on trade settlement. This started with a pilot scheme for cross-border trade settlement in renminbi in 2009 that had expanded to all mainland exporters and importers by 2012. This reflected the practical objective of allowing more Chinese corporates to conduct cross-border trade in their own currency to eliminate the currency risk. The effort met with considerable success as the share of mainland goods trade denominated in renminbi

Figure 1. Renminbi Cross-Border Trade Settlement



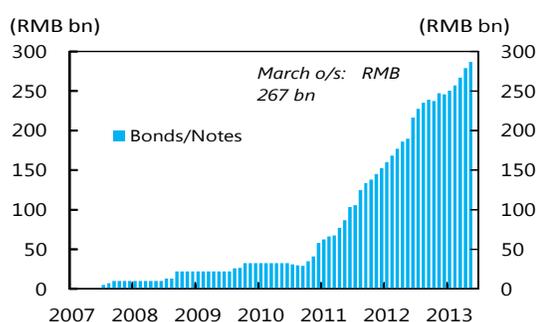
Source: People's Bank of China.

reached 11 percent. Adding trade in services to goods, the quarterly volume exceeds RMB 1 trillion in Q1 2013 for the first time (Figure 1).¹

This strong progress in renminbi trade settlement was not matched on the financing side. Most firms reportedly continued to denominate offshore treasury operations in dollars. This is attributed by market participants to the fact that offshore currency markets are more developed than offshore rates markets. There is reportedly good liquidity in renminbi spot, forwards and swap markets but renminbi interest rate swap and repo markets are still lacking. This leads corporate treasury managers to continue to operate in dollars where these markets are well developed, deep and liquid, which allow more effective hedging of interest rate and other risks. There has been substantial growth in offshore renminbi debt instruments, but secondary market liquidity is low partly owing to the lack of offshore money markets. The introduction of an offshore renminbi interest rate fixing in June 2013 (that is, a CNH HIBOR fixing) should help by anchoring pricing in offshore interest rate swap and repo markets.

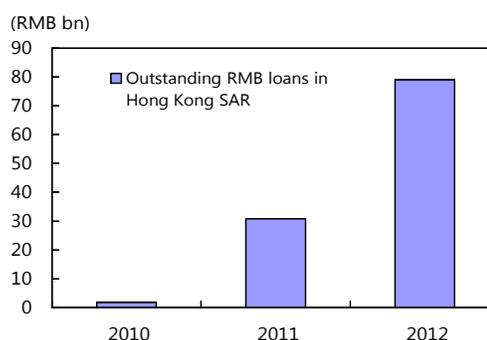
The stock of offshore renminbi financial assets expanded steadily with the supply of “Dim-Sum” bonds reaching RMB 267 billion by March 2013 (Figure 2). Renminbi bank loans in Hong Kong SAR also expanded, reaching RMB 89 billion by March-2013 (Figure 3). Both benefitted from liberalization measures that opened channels for offshore renminbi to flow back to the Mainland through renminbi denominated FDI and into mainland interbank bond, equity and fixed income markets, which allowed these onshore investments to be funded offshore. Finally, a wide range of specialized offshore renminbi products have been created, including equity REIT (listed in April 2011), renminbi Exchange-Traded Funds, insurance products, derivatives (offshore deliverable renminbi futures and options) and commodities (e.g., Gold ETFs, listed in February 2012).

Figure 2. “Dim-Sum” Bonds Outstanding



Source: Hong Kong Monetary Authority (HKMA)

Figure 3. Renminbi Loans in Hong Kong SAR



Growth in renminbi bank deposits, including certificates of deposits, has been less steady. They rose from 2 percent to 11 percent of total deposits in Hong Kong SAR in less than two years; but, then, peaked at RMB 700 billion in November 2011 and contracted. Only recently have they started to expand again, reaching of RMB 812 billion in March 2013 (Figure 4). This temporary stagnation in renminbi deposits was associated with an increase in the

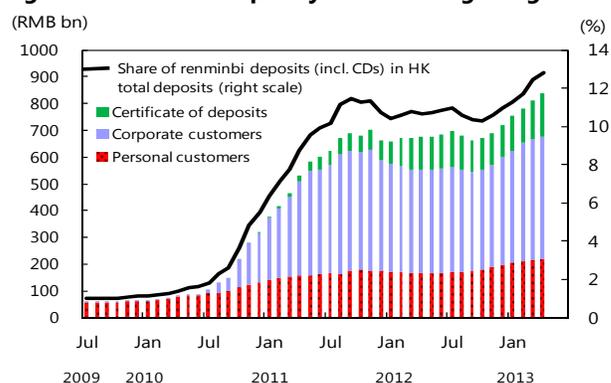
¹ This working paper uses information up to April 2013.

perceived risk of using the offshore currency, which led offshore investors to reduce renminbi holding.

These deposits represent a pool of renminbi liquidity in Hong Kong SAR that can be redeployed to support the expansion of offshore financial markets and products. The pool remained significantly

larger than the stock of renminbi financial products despite its contraction and, thus, did not constrain their growth. But, going forward, offshore renminbi liquidity will need to expand in parallel with assets to ensure progress in renminbi internationalization. In theory, the pool will be replenished by flows of onshore renminbi into offshore renminbi deposits in response to market incentives for arbitrage. However, the scale of these flows and, hence, the potential for arbitrage, are constrained by capital controls. This suggests that an analysis of the effectiveness of arbitrage can shed light on how these controls are limiting progress in renminbi internationalization.

Figure 4. Renminbi Liquidity Pool in Hong Kong SAR



Source: HKMA

III. ASSESSING RENMINBI INTERNATIONALIZATION BY ANALYZING ARBITRAGE

A. Defining Progress in Renminbi Internationalization

Progress in internationalizing the renminbi can be evaluated based on how well the offshore market functions as a substitute for the onshore market. To tell whether the two markets are integrated, we assess whether there are no unexploited arbitrage opportunities between them. This will be the case when the difference between the CNY and CNH exchange rates with the dollar (the “basis”) is small enough to remain in a “no-arbitrage” band, within which arbitrage is not profitable owing to transaction costs such as the bid-ask spread. A metric of the integration of the offshore and onshore markets can be derived by estimating a no-arbitrage band and then assessing the extent that the CNY-CN H basis stays within this band.

Estimation shows that the no-arbitrage band is quite wide. Moreover, the basis is outside the band for extended periods, indicating that the offshore renminbi is an imperfect substitute for the onshore renminbi. The differential is often large, indicating that investors and firms face significant “basis risk:” the risk that by using CNH in place of CNY could incur significant losses owing to volatility in the basis. An increase in the perceived basis risk makes investors and firms more reluctant to use CNH as a substitute for the CNY, holding back development of an international role for the renminbi. They either try to use the CNY itself—which is difficult due to capital controls—or the dollar where risks can be better hedged.

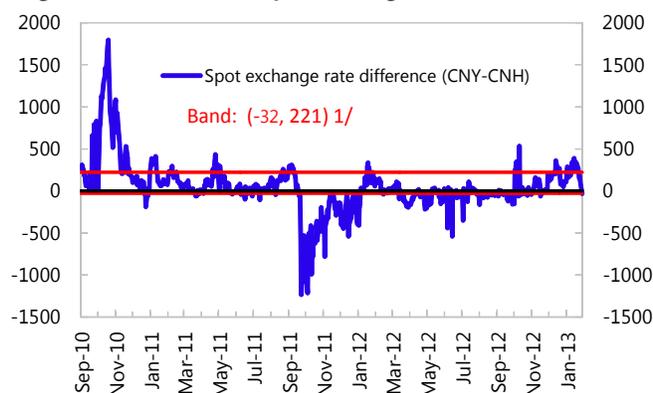
B. Estimating Integration of Onshore and Offshore Renminbi Markets

This research differs from other papers in the literature in that it assesses the integration of renminbi offshore and onshore markets in that it applies a Threshold Autoregression model (TAR) model to estimate the no-arbitrage band and checks how much the basis is outside the band. Other studies, for example HKMA (2012); Ding, Tse, and Williams (2012); Maziad and Kang (2012); and Wu and Pei (2012), assess renminbi onshore/offshore market linkages using Granger causality test or GARCH models. They focus on price discovery directions and volatility spillovers between the two markets. Estimation in this paper exploits the fact that within the band the basis follows a random walk as transaction costs make arbitrage unprofitable. In contrast, outside the band it follows an autoregressive process as arbitrage is profitable and moves the basis back towards the band. The estimated parameters of the autoregressive process indicate the speed of this convergence back to the band and will depend on the volume of the arbitraging capital flows between onshore and offshore markets possible under existing capital controls.

The data are differentials between the daily CNY and CNH (onshore and offshore) dollar spot exchange rates. The estimated width of the band is 253 pips, roughly one quarter of a percentage point (Figure 5). Statistical tests confirm that the basis follows a random walk within the band and an autoregressive process outside it (Annex Table 3). The data start in September 2010 when CNH first began to trade actively. Despite over 600 observations, the sample is relatively short and the estimated width of the band could be different for different sample periods, either for statistical reasons or because transaction costs can change with institutional market reforms. An example of how differences in market infrastructure can lead to different band widths comes from applying the TAR model to other onshore-off-shore exchange rate pairs; as is done for the differentials between the onshore three-month forward rate and (i) the offshore three-month nondeliverable forward rate (NDF) and (ii) three-month deliverable forward rate in Hong Kong SAR, respectively, as shown in the Annex.

The estimation results find limited

Figure 5. CNY and CNH Spot Exchange Rate Differentials



Sources: Bloomberg L.P.; and IMF staff estimations.

1/ Band is estimated with the TAR model on the sample of 1 September 2010–31 January 2013. Around 56 percent of observations are within the band.

Table 1. TAR Model Estimation Results

Dependent Variable: CNY-CN	Results
CNY weaker than CNH (pos. basis)	15 percent of time
Autoregressive coefficient	0.97***
Implied "half life"	25 days
CNY-CN basis trades within band	56 percent of time
CNY stronger than CNH (neg. basis)	29 percent of time
Autoregressive coefficient	0.88***
Implied "half life"	6 days

Note: *** indicates significance at the 1 percent level. The technical annex provides full estimation results.

integration between onshore and offshore markets. They show that the basis trade within the no-arbitrage band only 56 percent of the time (Table 1). This fact, together with the large, absolute positive and negative values for the basis (peaking at 1,795 and -1,235 pips, respectively), suggest users of offshore renminbi face relatively high basis risk, which serves to discourage them from using the CNH as a substitute for CNY. This awareness of basis risk may have increased with the sharp rise in the volatility in the basis in the second half of 2011, which may help explain the temporary stalling of CNH deposit growth as users became more cautious in holding CNH in place of CNY (Figure 4).

C. Arbitrage between Onshore and Offshore Markets and the Role of Capital Controls

The estimation results confirm that arbitrage works to steadily narrow the basis when shocks move it outside the no-arbitrage band. This is reflected in the highly significant coefficient on the autoregressive processes followed by the basis when outside the band. The coefficient estimates are fairly close to one, indicating that the convergence process is relatively slow and may reflect limits on the scale of arbitrating capital flows owing to capital controls.

The estimation results reveal an asymmetry in the speed with which capital inflow and outflow work to narrow divergences in the offshore and onshore exchange rates. Arbitrage is much slower when the CNH is stronger than the CNY than when it is weaker, specifically:

- When CNH trades at a premium to CNY, arbitrage takes an average of 25 days to close half the gap back to the band (the “half life”) (Table 1). Capital outflows from the mainland are needed for this arbitrage, and work to increase the supply of offshore renminbi liquidity. This was the case in the November 2010-May 2011 episode.
- When CNH trades at a discount to CNY, arbitrage takes an average of 6 days to close half the gap back to the band. This involves capital inflows to the mainland, reducing the supply of offshore renminbi liquidity. This was the case in September 2011-October 2012 period.

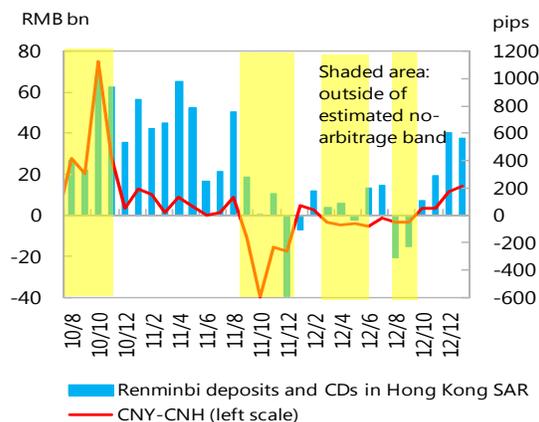
The faster rate of convergence in the latter case—when CNH trades at a discount to CNY—implies that capital controls are less restrictive with respect to arbitrating capital inflows to the mainland than outflows from the mainland. This difference may reflect the fact that recent liberalization measures have focused more on easing constraints on inflows than outflows (see section IV below), such as the opening of channels for renminbi denominated FDI and QFII that can be used to bring offshore renminbi funds onshore.

D. Sources of Divergence of Onshore and Offshore Renminbi Exchange Rates

The movement in the basis outside the no-arbitrage band will be driven by a number of factors that, along with capital controls, contribute to limited integration of onshore and offshore markets. The literature points to a range of potential factors, including market expectations for the renminbi, market risk sentiment, capital controls and offshore renminbi liquidity. For example, arbitrating capital flows would lead to changes in offshore renminbi liquidity that would be negatively correlated with the basis. This appears to be the case, with

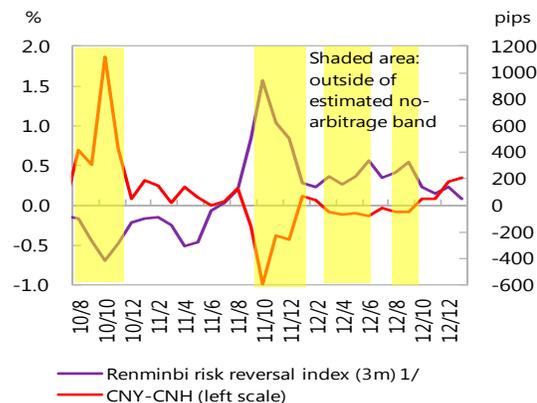
renminbi deposits and CDs in Hong Kong SAR surging when the CNH trades at a premium to the CNY, and vice-versa (Figure 6). The influence of shifts in investor sentiment can also be seen in the correlation between the basis and the renminbi risk reversal,² which is an index market sentiment (Figures 7).

Figure 6. Correlation of Basis and Renminbi Deposits and CDs in Hong Kong SAR



Sources: Bloomberg L.P., and IMF staff estimation.

Figure 7. Correlation of Basis and Renminbi Risk Reversal



Sources: Bloomberg L.P., and IMF staff estimation.
1/ Represents market view of the most likely direction of the spot movement over the next three months.

To confirm that the influence of these variables (Figures 6 and 7) on the basis is robust we estimate a VAR model to test their statistical significance and control for a range of other variables. The dependent variables in the VAR is the onshore-offshore renminbi differential; with the following explanatory variables found to have a statistically significant impact, as reflected in VAR impulse-response functions (see the Annex for technical details);

- the change in renminbi liquidity as measured by deposits and CDs in Hong Kong SAR (Figure 6);
- the three-month renminbi risk reversal index (Figure 7);
- A dummy variable for the opening of new channels for renminbi cross-border flows (see Annex for detailed definitions).
- A dummy for when the quota is hit on the size of the aggregate net position that Hong Kong SAR banks can square with the clearing bank at onshore rates for trade-related renminbi payments.

The VAR results confirm that the basis is affected by changes in offshore renminbi liquidity. This is the case even when controlling for the endogeneity that results from the fact that the arbitrage narrowing the basis also affects offshore liquidity. The results also show that shift

² The reversal index is defined as the implied volatility for call options minus the implied volatility for put options on the base currency with the same delta. It can be interpreted as the market view of the most likely direction of the spot movement over the next maturity date.

in investor sentiment contributes to significant movements in the basis. Finally, liberalization policy measures also have an independent effect on the basis.³ Overall, these results suggest that there is considerable scope for policy to affect the arbitrage working to narrow the basis, to enhance onshore-offshore renminbi market integration, and to reduce basis risk. The next section therefore turns to the role of capital account liberalization policy.

IV. ROLE OF CAPITAL ACCOUNT LIBERALIZATION IN RENMINBI INTERNATIONALIZATION

A. Evolution of China's Capital Account Liberalization Strategy

In recent years, mainland capital account liberalization has been increasingly geared towards supporting renminbi internationalization. This was partly in response to weaknesses in the international monetary system revealed in the 2008–09 global financial crisis. Specifically, the availability of dollars for trade and other cross border financing in global markets temporarily dried up during the crisis, highlighting a risk of relying on a single reserve currency. Another, more recent, consideration is that reliance on the dollar dominated system is the exposure to US unconventional monetary policies that results in global monetary and financial conditions that are excessively lax from China's perspective. This shift in policy focus is clearly evident in liberalization measures announced since 2009 (Table 2). These triggered the rapid expansion in renminbi trade settlement and offshore renminbi liquidity (Figures 1 and 4).

Renminbi internationalization and capital account liberalization are seen as a mutually-reinforcing process by the Chinese authorities (Zhou, 2012). This is part of broad strategy of financial sector reform and development that is aligned with a “gradual and controllable” approach to capital account liberalization. However, the goal of promoting wider use of the currency in trade and related international financial transactions is broader in scope than liberalization in that it also covers nonresidents' renminbi-denominated assets and liabilities, and off-balance sheet (e.g., forwards and derivatives) activities (He, 2012).

Hong Kong SAR has been the primary location in which the offshore renminbi markets developed. It provided a testing ground for the various initiatives to develop the renminbi as an international currency. This reflects, in part, the close co-operation between the mainland authorities and Hong Kong SAR that facilitated the monitoring and management of the process. The launch of offshore renminbi settlement and banking in Hong Kong SAR focused initially on international trade, but the existence of the renminbi platform in Hong Kong SAR facilitated development of other type of renminbi financing and investment activities. HKMA actions have also supported renminbi market by increasing flexibility in regulations designed to limit risks from offshore use of the renminbi as banks demonstrated the capacity to manage these risk more effectively (Tables 2 and 3).

³ A number of variables turned out to be statistically insignificant and, thus, are not reported, notably the difference between the onshore three-month forward rate and the three-month NDF, used as a proxy for expectation of futures changes in the basis.

The econometric analysis in Section III suggests that capital account liberalization measures have played a decisive role in advancing offshore use of the renminbi. However, the Chinese authorities' willingness to implement such measures depends on the effect on mainland capital flow and whether it is consistent with their broader objectives. To assess this, we look at the pattern of capital flows associated with liberalization. How this has affected bilateral flows with Hong Kong SAR given its central role? And, finally, how measures may need to evolve relative to those in Table 2 to sustain the process?

Table 2. Key Mainland China Capital Account Liberalization Measures

Date	Measures liberalizing flows in general	...and renminbi-denominated flows
1980	Special Economic Zones to promote trade and attract FDI	
1984	Some coastal cities opened to FDI	
1993	Mainland firms listed in Hong Kong SAR (in Hong Kong dollars)	
1999	FDI liberalization extended to all provinces	
2001	Financial institutions are allowed to issue bonds in the international markets	
	WTO accession	
2002	QFII scheme allowing foreign investment in domestic stock and bond markets	
2003		Offshore RMB settlement infrastructure created in Hong Kong SAR
2004		Deposits-taking and exchange for individuals and designated merchants in Hong Kong SAR
2006	QDII scheme relating to mainland portfolio investment abroad	
2007		Chinese financial institutions allowed to issues RMB bonds in Hong Kong SAR
2008	Mainland banks allowed to provide loans to firms for use in cross-border M&A	
2009		Trade settlement in RMB allowed
2010		Foreign companies were authorized to issue RMB-denominated bonds in Hong Kong SAR
2011		Trade settlement scheme expanded ODI settled in RMB RMB FDI permitted
2012		RMB QFII allowed
2013		Creation of Qianhai special economic zone where the two-way cross-border RMB lending is allowed RMB QFII scheme expanded

Table 3. Measures to Support RMB Market Development in Hong Kong SAR

June 2007	RMB risk management limit introduced by the HKMA
December 2010	Net open position (NOP) introduced and set at 10 percent of banks' RMB assets and liabilities (whichever is higher)
July 2011	Overall NOP maintained at 10 percent but deliverable forward positions in the opposite directions are allowed to offset any excess NOPs.
January 2012	Doubling of RMB NOP limit from 10 percent to 20 percent
May 2012	20 percent RMB NOP limit ended. Banks allowed to set their own RMB NOP limit in consultation with the HKMA
June 2012	The RMB risk management limit was replaced by a 25 percent RMB liquidity ratio computed on the same basis as the statutory liquidity ratio
April 2013	RMB NOP limit removed and the 25 percent minimum liquidity ratio for RMB lifted

B. The Impact of Liberalization Measures on Mainland Capital Flows

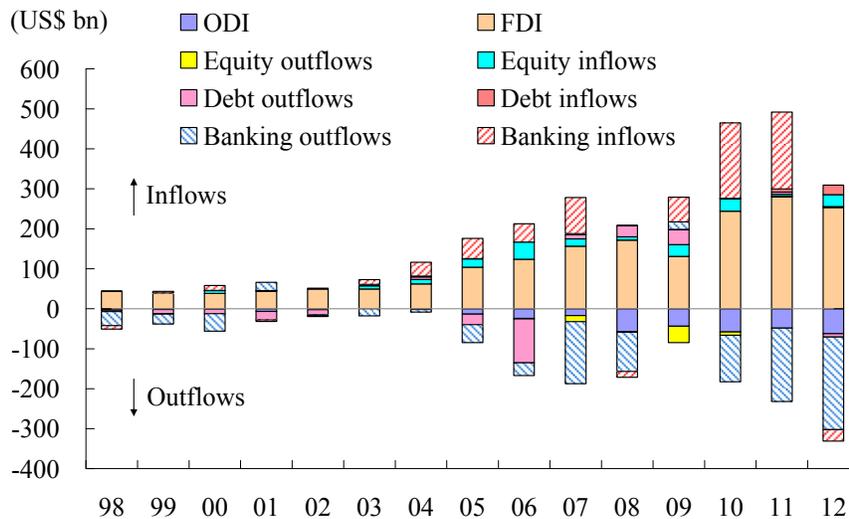
Mainland China's capital account liberalization strategy follows a gradual process aimed at avoiding the volatility in capital flows with the following features:

- Liberalization of direct investment ahead of portfolio investments;
- Liberalization of capital inflows to a greater extent than outflows;
- Measures are typically first implemented as a pilot on a reduced scale to test their impact and then expanded to cover more economic sectors and regions;
- Liberalization measures often involve a quota system or the need for approval of transaction by authorities' (often over a threshold size); and
- Implementation involves close monitoring of flows to assess the effect of measures.

These features are reflected in the expansion in the gross inflow and outflows in China's balance of payments (Figure 8) and capital account liberalization measures listed in Table 2. This expansion has been relatively smooth despite the global financial crisis. Private capital inflows have expanded more than outflows, with FDI making up a large portion of these inflows. In contrast, equity inflows and outflows have been relatively small, reflecting the quota system imposed under the Qualified Domestic Institutional Investor (QDII) and Qualified Foreign Institutional Investor (QFII) schemes.⁴

⁴ QFII scheme allows specified foreign investors to make portfolio investments inside Mainland China while QDII scheme permits Mainland investors to make portfolio investments outside Mainland China.

Figure 8. Mainland China's Private Capital Flows



Source: State Administration of Foreign Exchange (SAFE) of the People's Republic of China (PRC).

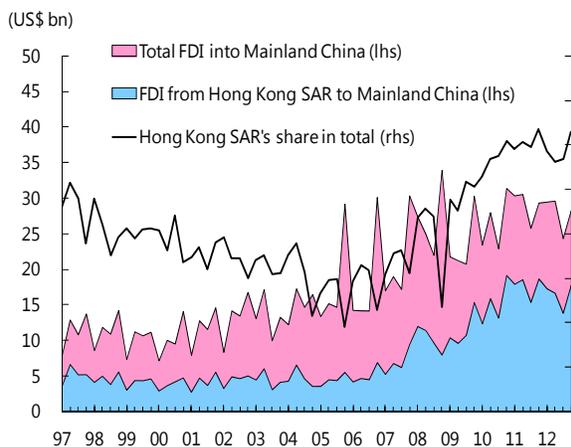
C. Hong Kong SAR's Role in Mainland Capital Account Opening

China's capital account liberalization was associated with an expansion in Hong Kong SAR's role as a financial gateway to the Mainland where growth in the offshore use of the renminbi has been concentrated. Bilateral capital flows between the two grew rapidly in recent years and, although comprehensive bilateral flow data are lacking, several measures of bilateral flows between China and Hong Kong SAR illustrate this role for Hong Kong SAR:

- Hong Kong SAR's share in Mainland China's inward FDI rose to around 60 percent in the past few years (Figure 9). This partly reflects foreign companies increasing tendency to set up companies in Hong Kong SAR and use them as a springboard for investing in Mainland China. A significant portion of this investment was by firms in Hong Kong SAR with a mainland Chinese interest or ownership, often funded by Chinese banks' foreign operations.
- Hong Kong SAR accounted for around 50 percent of Mainland China's overseas direct investments (ODI) in recent years (Figure 10). Some of these investment flows were related to the surge since 2008 in merger and acquisition activities involving mainland entities listed in Hong Kong SAR. These transactions were often executed via mainland companies' subsidiaries or local offices in Hong Kong SAR. The Hong Kong Stock Exchange became the leader in global equity issuance for several years owing partly to issuance by mainland companies.
- For portfolio investment flows, an average of 50 percent of QDII funds was allocated to Hong Kong SAR, according to estimate by Yao and Wang (2012) (Figure 11).

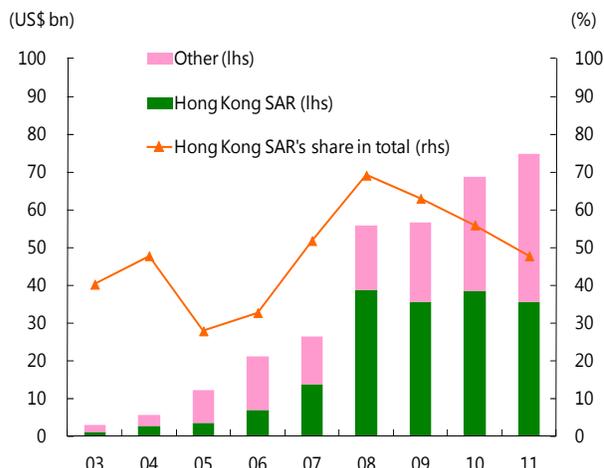
- Hong Kong SAR banks' lending to Mainland-related companies also boosted the bilateral banking flows between the two in 2010–12, as revealed by the surge in Hong Kong SAR banks' external claims to Mainland China (Figure 12).

Figure 9. Mainland China's Foreign Direct Investments (FDI) by Destination 1/



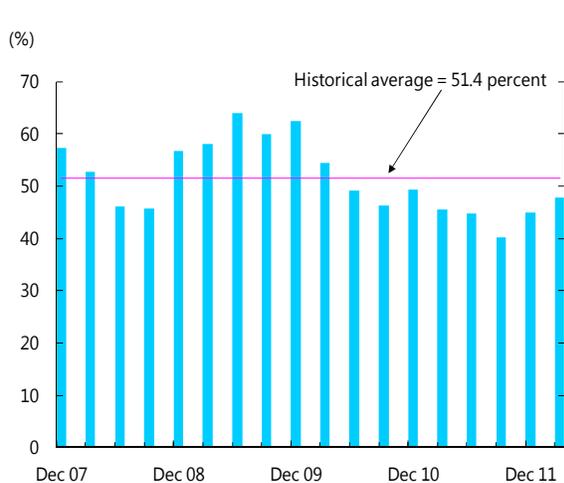
Source: Ministry of Commerce, PRC.
1/ Data refer to utilized FDI.

Figure 10. Mainland China's Overseas Direct Investments (ODI) by Destination



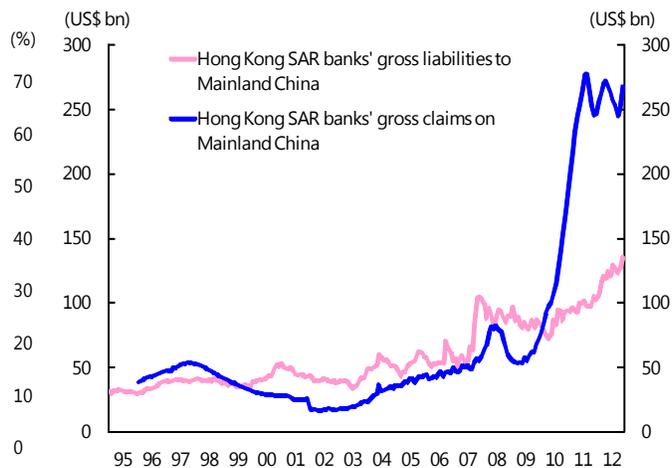
Source: Ministry of Commerce, PRC.

Figure 11. Average Asset Allocation to Hong Kong SAR by Equity-Oriented QDII Funds



Source: Yao and Wang (2012).

Figure 12. Mainland China's External Positions vis-à-vis Hong Kong SAR Banks



Source: Hong Kong Monetary Authority.

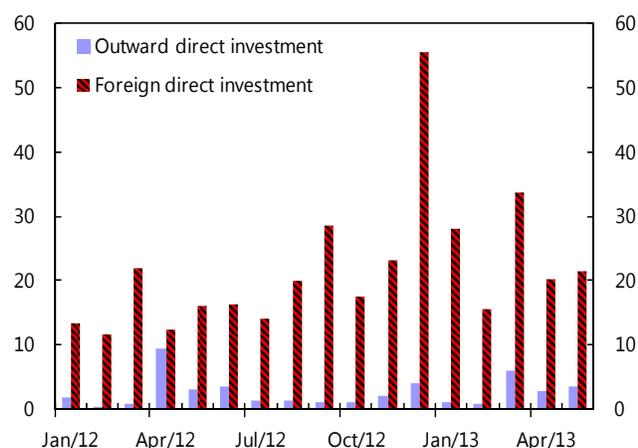
This gateway role was strengthened by development of the offshore renminbi business in Hong Kong SAR. China's renminbi denominated cross-border flows are mostly channeled through Hong Kong SAR, where the offshore renminbi payments and financial infrastructure is located. As these expanded, so did bilateral flows with Hong Kong SAR. The main forms of renminbi denominated flows are:

- Renminbi denominated cross-border trade settlement with the mainland started with a pilot scheme was launched in July 2009 and expanded to all trade and current account transactions over the next two years. The share of renminbi denominated trade expanded rapidly, reaching 16 percent in Q1 2013.

- Renminbi denominated mainland inward and outward direct investment started in 2011, when they accounted for 12 percent and 4 percent of the total, respectively. Renminbi FDI inflows have grown rapidly since then but ODI outflows have small relative to inflow (Figures 13 and 14).
- Renminbi denominated portfolio investments; with investment in the mainland interbank bond market by foreign banks and monetary authorities starting in August 2010. Then, in December 2011, the renminbi QFII scheme was launched with quota for RMB 20 billion, which was expanded to RMB 70 billion in April 2012.

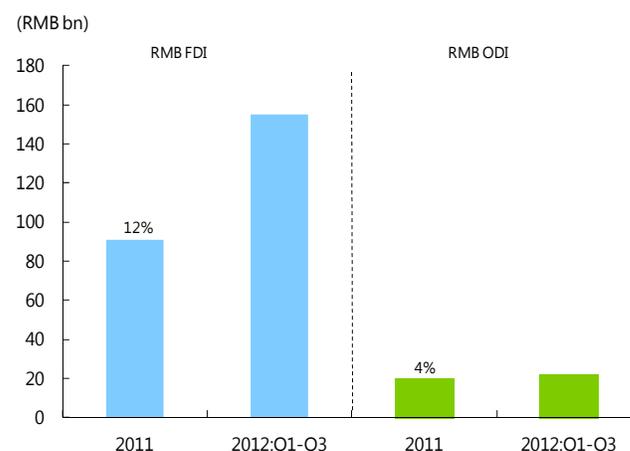
Figure 13. Mainland China's Renminbi FDI and ODI, Monthly Flows

(In billions of RMB)



Source: Department of Commerce., PRC.

Figure 14. Mainland China's Renminbi FDI and ODI, Percent of Total 1/

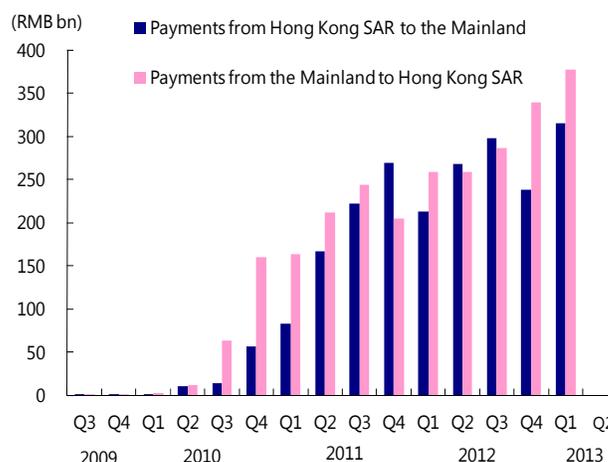


1/ The percentages refer to their estimated shares in total FDI and ODI respectively.

D. Renminbi Internationalization and the Offshore Renminbi Liquidity Pool

Development of an offshore role for the renminbi has depended on a pool of offshore renminbi liquidity in Hong Kong SAR that could be redeployed to support the expansion of offshore financial markets and products (Figure 14). Renminbi internationalization measures initially contributed to the rapid growth in this pool by creating stronger incentives to settle imports in renminbi than exports. This led to larger flows into Hong Kong SAR as payment for imports than outflows to Mainland China as payment for exports (Figure 15). This incentive reportedly derived from the greater difficulty in collecting value added tax rebates for exports denominated in renminbi versus in dollars. It

Figure 15. Cross-Border Renminbi Trade Settlement with Hong Kong SAR



Source: Hong Kong Monetary Authority

disappeared when this difference in the tax treatment was eliminated and, now, inward and outward flows for renminbi trade settlement are roughly in balance; and, thus, are no longer a net source of offshore renminbi liquidity.

The offshore renminbi pool is still significantly larger than the stock of renminbi financial products. Thus, despite its recent contraction, it has not constrained the growth of renminbi financial products and markets. But, going forward, their rapid growth will continue to draw on this liquidity, eventually tightening liquidity conditions unless this pool is replenished. Recent liberalization measures have boosted this growth but less much to expand the pool of offshore liquidity but expanding outflows. Measures allowing renminbi denominated FDI, for example, encouraged issuance of dim sum bonds as the proceeds can be repatriated back to Mainland China directly as FDI. Similarly, the expansion in the quota for renminbi QFII has widened the channels for portfolio flows back to the Mainland.

As rapid growth of offshore renminbi products and markets draws on offshore renminbi liquidity, the pool can be replenished by arbitraging flows of renminbi from onshore to Hong Kong SAR. However, the scope for arbitrage and scale of these flows is constrained by capital controls. Endogenous mechanisms such as a rise in offshore renminbi interest rates should adjust to pull funds offshore into the pool. However, there is a risk that this could slow renminbi internationalization if, for example, interest rates rise, effectively tightening liquidity conditions. The alternative of a more balanced approach to capital account liberalization involving targeted measure to facilitate outflows into the offshore pool to avoid excessive tightening of liquidity conditions could lead to better outcomes.

V. CONCLUSIONS

Renminbi internationalization has proceeded rapidly in recent years but econometric analysis finds that much deeper market integration is needed for offshore markets to function as a close substitute for onshore markets. Offshore users of the renminbi face significant basis risk where volatility in the basis can lead to large divergences between the onshore (CHY) and offshore (CNH) renminbi exchange rates. The analysis shows that sharp widenings in this basis are triggered by shifts in investor sentiment with capital controls playing a role in limiting arbitrage. It shows that arbitraging capital flows narrow this basis slowly, reflecting limits on the size of these flows from capital controls. Moreover, arbitraging inflows narrowed the basis much more quickly than arbitraging outflow, which could reflect China's more extensive recent liberalization of controls on inflows. These results confirm the important role capital account liberalization plays in renminbi internationalization.

A review of liberalization measures show that the authorities began promoting offshore use of the renminbi much more actively in the wake of the global financial crisis. This effort was reinforced by steps by the Hong Kong SAR authorities to support development of offshore markets in the city. The focus of these measures on renminbi trade settlement, FDI and banking flows is reflected in the structure of capital flows vis-à-vis China and have expanded Hong Kong SAR's role as a financial gateway to China. The analysis confirms that controls on capital inflows have been eased more than on outflows.

Liberalization measures have boosted growth of renminbi financial products in Hong Kong SAR by providing more scope for deploying funds on the mainland. The offshore pool of renminbi liquidity that supports this activity recovered after contracting last year and, going forward, will need to expand in line with demand for renminbi financial products. The pool should be replenished by arbitraging flows of renminbi from the Mainland but the scale of these flows is constrained by capital controls. A rise in offshore renminbi interest rates should pull funds offshore into the pool, but there is a risk that this could be disruptive for renminbi internationalization if it involves a large rise in interest rates or if flows through unofficial channels prompt a crackdown. A balance liberalization of capital inflows and outflows would help ensure adequate flows into the offshore liquidity pool and avoid the risk of an excessive tightening of liquidity conditions that could disrupt RMB internationalization.

Technical Annex: TAR Models and Estimation Results

Methodology: Threshold Autoregressive (TAR) models

The simplest class of TAR models is the Self-Exciting Threshold Autoregressive (SETAR) model, where state determining variable (i.e. threshold variable) is the dependent variable itself. An asymmetric band SETAR(1) model can be shown as follows,

$$\begin{cases} z_t - k_1 = \rho_1(z_{t-1} - k_1) + \varepsilon_{1t} & \text{if } z_{t-d} \leq k_1 \\ z_t = z_{t-1} + \varepsilon_{2t} & \text{if } k_1 < z_{t-d} < k_2 \\ z_t - k_2 = \rho_2(z_{t-1} - k_2) + \varepsilon_{3t} & \text{if } z_{t-d} \geq k_2 \end{cases}$$

where $\varepsilon_{it} \sim i.i.d. N(0, \sigma_i^2)$, $\rho_i \in (0,1)$, $k_1 < k_2$ and $d \in (0,1)$. Such a process makes the model nonlinear for at least two regimes, but remains locally linear, i.e. piecewise linear autoregressive models (Tsay, 1989; Tong, 2011). Model coefficients and thresholds can be estimated by maximum likelihood estimation or conditional least square (Tong, 2011; Hansen, 1997). Thresholds may be specified exogenously or estimated by fitting the model for a grid of different, by default all values of thresholds, and taking the best fit as the final estimate with the sum of squared residuals (SSR), AIC as possible criteria. There could be several variations for the SETAR model, e.g. alternative dynamic specifications for regressors, different deterministic regressors (i.e. constant and trend) combinations, different lags for the threshold variable, among others.

This model has been widely applied to finance studies, such as exchange rate, stock returns, interest rates (Hansen, 2011). This study applies SETAR(1) to test the law of one price (exchange rate) for renminbi between onshore and offshore markets. In this case, $[k_1, k_2]$ represents transaction cost band wherein arbitrage is not profitable, and therefore, z_t follows a random walk within the band as there are no economic forces pushing prices together.

Data and descriptive statistics

Daily closing spot and 3-month forward exchanges rates in onshore and offshore markets are used in this study. More specifically,

Spot markets: (CNY – CNH)*10000, 2010/09/01 – 2013/1/31
 Forward markets: (CNY 3m fwd – NDF 3m)*10000, 2005/11/01 – 2013/1/31
 (CNY 3m fwd – CNH 3m fwd)*10000, 2011/07/01 – 2013/1/31

Annex Table 1 shows the descriptive statistics for the three pairs of rate differentials. As shown in the table, there exist large absolute disparities between the three pairs of rates. For instance, the absolute positive and negative CNY-CNH spot rates differentials reached almost 1800 and 1300 pips, respectively.

Annex Table 1: Descriptive statistics for onshore-offshore rates differentials

	CNY – CNH	CNY 3m fwd – NDF 3m	CNY 3m fwd – CNH 3m fwd
Mean	54.5	165.2	-96.2
Median	19.0	165.0	-62.0
Maximum	1795.0	1229.0	371.0
Minimum	-1235.0	-2120.0	-1283.0
Std. Dev.	314.1	335.7	222.1
Observations	628	1799	377

Linearity tests are conducted for the three pairs of rates differentials, indicating that these rates differentials are non-linear with three regimes (Annex Table 2). This would confirm that it is proper to apply SETAR(1) model.

Annex Table 2: Linearity tests for onshore-offshore rates differentials

	CNY – CNH	CNY 3m fwd – NDF 3m	CNY 3m fwd – CNH 3m fwd
1-regime vs 2-regime:			
TAR-F test	19.47089	40.99662	60.39284
p-value	<0.001	<0.001	<0.001
1-regime vs 3-regime:			
TAR-F test	34.57390	64.00236	133.43979
p-value	<0.001	<0.001	<0.001
2-regime vs 3-regime:			
TAR-F test	14.64742	22.4926	62.9147
p-value	<0.001	<0.001	<0.001

TAR model estimation results

Annex Table 3 summarizes estimation results of TAR model for onshore-offshore rates differentials. The spot rates differentials have been intensively discussed in the text, so this annex only summarizes estimation results for forward rates differentials.

- *CNY 3m fwd – NDF 3m* The no-arbitrage band size is around 490 pips, which covers 61% of the sample (Annex Figure 1). Compared to the onshore market, renminbi forward rates were mostly traded at premium (except for a short period after the Lehman bankruptcy) in the offshore NDF market. So the estimated lower threshold is higher than zero. This indicates that arbitrage would occur more easily when NDF is at discount compared to onshore deliverable forward rate.
- *CNY 3m fwd – CNH 3m fwd* The no-arbitrage band size is around 300 pips, which covers around 50% of the sample (Annex Figure 2). Trading in the CNH deliverable forward market began active after renminbi appreciation expectation reversed, and therefore, renminbi forward rates were mostly traded at discount in the offshore deliverable forward market. As such, the estimated upper threshold is smaller than zero, indicating that arbitrage may occur more easily when CNH 3m forward rate is at premium compared to its onshore counterparty.

Annex Table 3: TAR model estimation results for onshore-offshore rates differentials

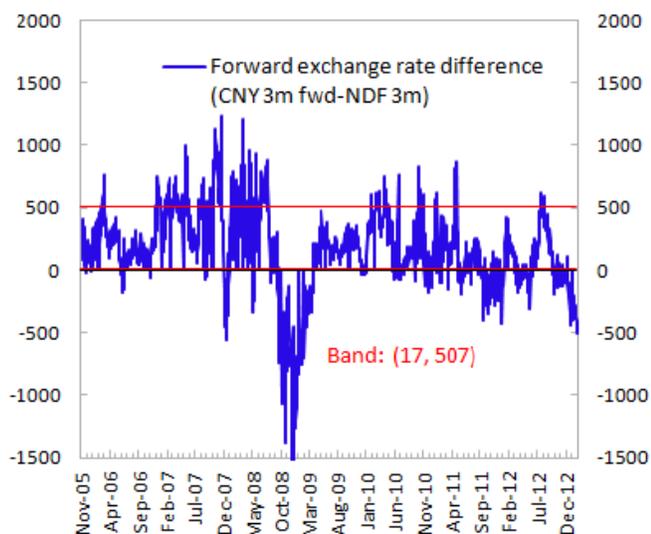
	CNY – CNH	CNY 3m fwd – NDF 3m	CNY 3m fwd – CNH 3m fwd
Thresholds (k_1, k_2)	(-32, 221)	(17, 507)	(-285, -18)
Lower regime	<i>28.75% of sample</i>	<i>25.25%</i>	<i>14.4%</i>
ρ_1 (std. dev.)	0.881*** (0.031)	0.933*** (0.018)	0.735*** (0.041)
Time trend (std. dev.)	0.022 (0.026)	0.005 (0.005)	-1.08*** (0.226)
Half-lives of shocks	<i>6 trading days</i>	<i>10</i>	<i>3</i>
No-arbitrage band	<i>55.91% of sample</i>	<i>60.57%</i>	<i>49.07%</i>
Unit root (root value)	Yes (0.938***)	Yes (0.994***)	Yes (0.975***)
Time trend (std. dev.)	-0.034* (0.020)	-0.012 (0.020)	0.030 (0.045)
Upper regime	<i>15.34% of sample</i>	<i>14.18%</i>	<i>36.53%</i>
ρ_2 (std. dev.)	0.972*** (0.019)	0.912*** (0.022)	0.683*** (0.085)
Time trend (std. dev.)	-0.100** (0.040)	-0.012 (0.020)	0.0872** (0.042)
Half-lives of shocks	<i>25 trading days</i>	<i>8</i>	<i>2</i>
AIC	5962	17575	3466
BIC	5998	17619	3497
Observations	628	1799	377

Notes: (1) Half-lives of shocks are calculated as $-\log(2)/\log(\rho)$;

(2) *** 1% significance, ** 5% significance, * 10% significance.

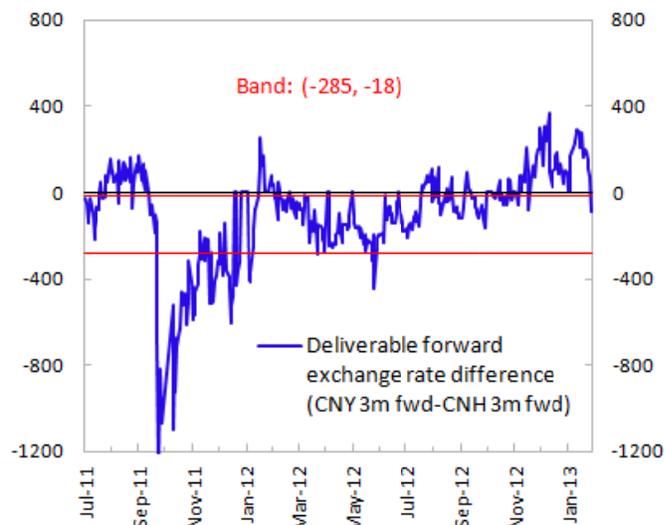
Source: IMF staff estimations.

Annex Figure 1: Onshore forward and NDF rates differentials and estimated band (pips)



Sources: Bloomberg L.P.; and IMF staff estimations.

Annex Figure 2: Onshore-offshore deliverable forward rate differentials and estimated band (pips)



Sources: Bloomberg L.P.; and IMF staff estimations.

What factors drive onshore-offshore spot rates to diverge and converge?

For this question, the literature suggests several factors, including fund flows for the purpose of arbitrage, investors' opinion differences, structural arrangement related shocks, market risk sentiment, among others. Using monthly data from August 2010 to January 2013, this study conducts empirical tests to examine whether there exists arbitrage between onshore and offshore markets that helps rates differentials to converge. Variables selected for the tests include,

- *Change in the onshore-offshore renminbi basis (DCNYCNH)*: the dependent variable.
- *The change in deposits and CDs in Hong Kong SAR (XRDPD)*: a measure for offshore renminbi liquidity.
- *Differences in investors' opinion (DCNYNDF3M)* Investors in different markets may form different views over the diverse information or even the same information. Over the time, investors' opinion may converge, which would bring down onshore-offshore spot rates differentials. A simple indication for this would be investors' perception on renminbi forward rates, so we use the onshore 3-month deliverable forward rate – NDF 3-month rate differentials as a proxy.
- *The 3-month renminbi risk reversal (CNYR3M)*: index is used as a proxy for investor market risk sentiment, capturing shift in balance in expectations of changes in the value of the (onshore) renminbi (see footnote 1).
- *Quota on trade-related inflows (DQUOTA)*: this dummy variable takes a value of 1 or -1 when the quota limits imposed by the PBC on the size of the aggregate net position that Hong Kong banks can square with the clearing bank (i.e. the Bank of China, Hong Kong SAR) at onshore rates for trade-related renminbi payments (and which is an important

arbitrage channel for capital inflows). The quota was hit twice, triggering sharp moves in the basis.

- *Renminbi capital flow liberalization measures (DPOLICY)*: this dummy variable captures the opening of new channels for renminbi cross border flows, making arbitrage easier. It increases by 1 when an additional channel (e.g. renminbi ODI, FDI, QFII, etc.) opens up (see Section IV).

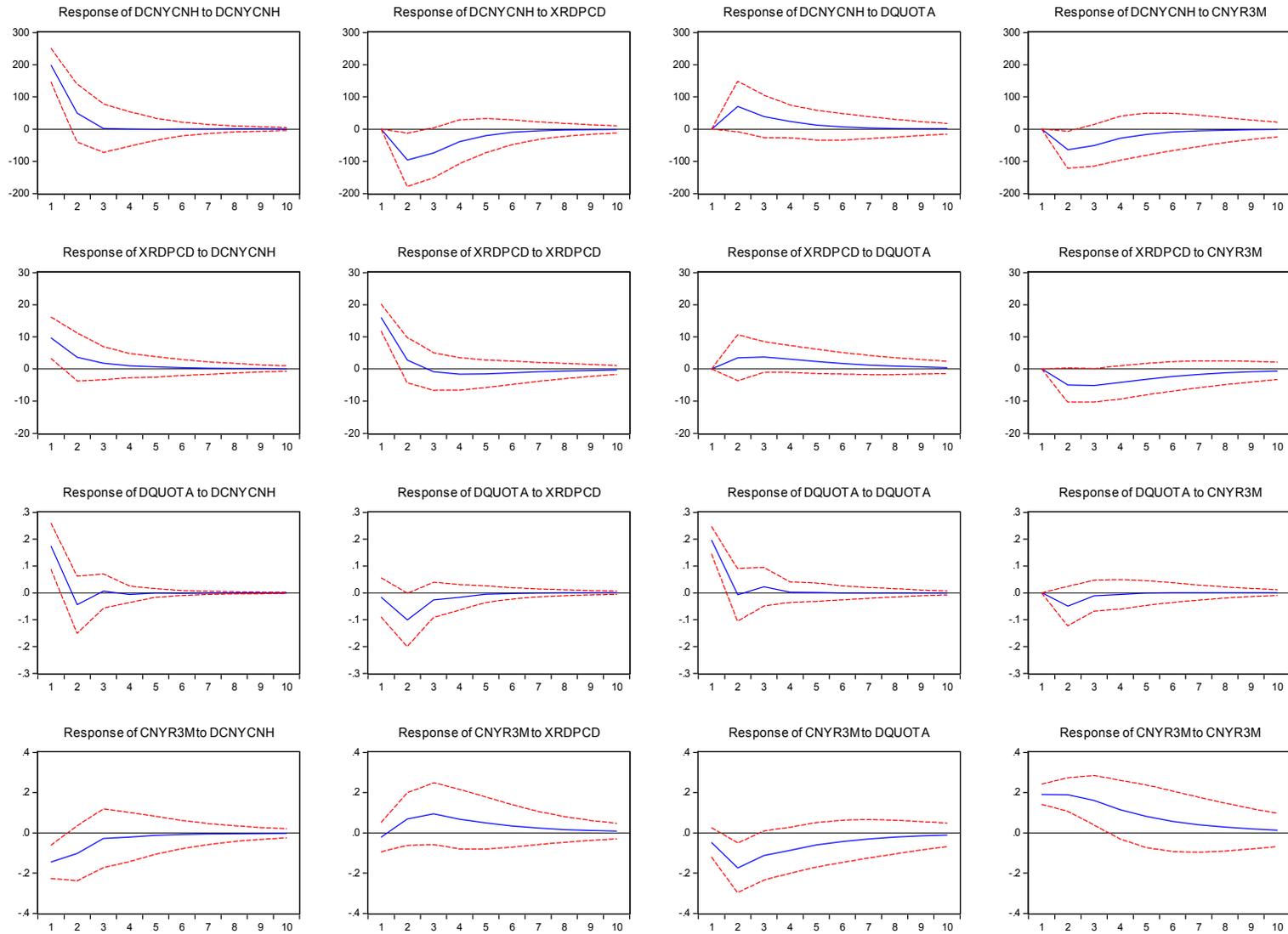
Annex Table 4 summarizes OLS and reduced-form VAR estimation results, and Annex Figures 3 and 4 present the impulse responses of CNY-CNH differentials and new renminbi deposits and CDs in the VAR. Overall, we may conclude that arbitrage is triggered when CNY-CNH differentials widened (Annex Figure 4: *XRDP* positively responds to *DCNYCNH*), and subsequently, arbitrage closes CNY-CNH differentials (Annex Figure 3: *DCNYCNH* negatively responds to *XRDP*). Investors' opinion difference seems not significantly affect CNY-CNH differentials, which might be due to the monthly frequency of the data as investors' views tend to change fast.

Annex Table 4:

Dependent variable: DCNYCNH (CNY-CNH)	OLS (std. dev.)	VAR_1 (std. dev.)	VAR_2 (std. dev.)
<i>Constant</i>	454.09 (190.62)	442.84 (133.10)	409.80 (132.35)
<i>DCNYCNH</i> (CNY-CNH, 1 period lag)		0.10 (0.26)	0.07 (0.26)
<i>DCNYNDF3M</i> (CNY 3m fwd – NDF 3m fwd, 1 period lag)	-0.33 (0.26)	-0.35 (0.27)	
<i>XRDP</i> (New RMB deposits& CDs in HK, 1 period lag)	-6.18 (3.13)	-6.31 (2.24)	-6.16 (2.27)
<i>CNYR3M</i> (CNY risk reversal index-3m, 1 period lag)	-406.11 (122.72)	-377.64 (144.85)	-334.31 (142.76)
<i>DQUOTA</i> (Event of hitting RMB cross-border trade settlement quota, 1 period lag)	332.53 (117.16)	296.22 (178.92)	277.25 (180.75)
<i>DPOLICY</i> (RMB internationalization policy dummy)	-87.61 (57.73)	-85.67 (48.88)	-88.11 (49.51)
Adjusted R-squared	0.55	0.50	0.49
AIC	13.49	13.60	13.60
Observations	30	29	29

Annex Figure 4. Impulse Responses VAR2

Response to Cholesky One S.D. Innovations ± 2 S.E.



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