

Intraday Seasonality in the Two Chinese Yuan Markets

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Abstract

The renminbi(RMB) has only been allowed to trade in the Shanghai foreign exchange market adopting a crawling peg system and the Hong Kong foreign exchange market following a free float system without capital regulation.

The purpose of this paper is to analyze the characteristics of intraday seasonality in each market using high frequency data. The main conclusions are as follows. First, we find U-shaped intraday seasonality patterns in the Shanghai market but could not confirm similar patterns in the Hong Kong market. Second, there exist strong correlations between return volatilities and quote ratios for both exchange rate for RMB /dollar. Third, we confirm quotes from New York and European countries at midnight when exchanges in Asian countries, including China and Hong Kong, are not open for business. Of particular interest is the way quotes are placed by the Bank of China (Hong Kong). Lastly, quotes in the Hong Kong market are less than those in the Shanghai market during normal market conditions, but sometimes sharply increase. This suggests that the Hong Kong market is complementarily used during periods of financial stress involving liquidity shortages.

JEL Category: G2, F31, G15

Keywords: Intraday seasonality, High frequency Data, Renminbi(RMB)

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1. Introduction

In recent years, turnover of Chinese currency, renminbi (RMB) has increased in the global financial market. However, RMB trading is only permitted in Hong Kong and Shanghai. The two markets have quite different systems. On 22 July 2005, the Shanghai onshore market (CNY), moved from a fixed rate system (US dollar peg) to a crawl-like-arrangement under which the exchange rate band is fixed and central parity changes each day. The Chinese monetary authority frequently intervenes into CNY foreign exchange markets to maintain the trading band. Moreover, there are several trading restrictions, including the requirement that traders live in Shanghai.

In contrast, the offshore foreign exchange market in Hong Kong, known as the CNH market, has adopted a free-float system and RMB transactions may be conducted by residents or non-residents without restrictions. Regulation of the CNH is relatively lenient. However, capital movement from Hong Kong to mainland China is generally prohibited. Financial institutions and banks are authorized to trade at the CNY market exchange rate, as long as they have a trade settlement certificate from the Bank of China (Hong Kong) and a corresponding bank in mainland China.

The purpose of this study is to analyze intraday seasonality of one currency (RMB) relative to the two different systems using high frequency RMB data extracted from Thomson Reuter Tick History. Using data from September 2010 to August 2013 that includes transaction information and bid-ask limit orders timed to the thousandth of a second, Cheung and Rime (2014) found evidence of the interconnectedness of the onshore and offshore rates. Namely, CNH order flow affects both the CNH and CNY exchange rates. Further, while both exchange rates usually track each other, they found evidence of large disparities during periods of liquidity stress. Maziad and Kang (2012) examined the transmission between CNY market and CNH market using daily data from August 2010 to September 2011 using a bivariate GARCH model. They find that developments in the CNY spot rate influence both the spot and forward rates in the CNH market but that the CNH forward market appears to move ahead of the CNY forward market under normal market conditions (absence of financial stress), while under conditions of financial stress offshore, exchange rate movements of CNH impacts the CNY spot rate and volatility spillovers exist in both directions. Ding, Tse and

Williams (2014) observed a linkage among daily returns of the CNY, CNH, and NDF (non-deliverable forward) markets in September 2009 to June 2011 based on VAR. They present a puzzle in that price discovery exists for the NDF exchange rate that is restricted to foreign participants and is settled in a foreign currency whereas the onshore exchange rate (CNY) has little linkage with the offshore exchange rate (CNH).

These previous studies are different in that they do not focus on intraday seasonality of the RMB. Ito and Hashimoto (2006) examined intraday seasonality patterns of the USD-JPY and Euro-USD using high frequency data of EBS of sample from 1 January 1999 to 31 December 2001. They demonstrate a double U-shaped distribution brought about by participants in Tokyo and London depicted in a Figure with time on horizontal axis and quote change frequency and trading volume on the vertical axis. Furthermore, Ito and Hashimoto (2006) insist that there is negative correlation between the change rate of price and bid-ask spread that is different from the stock market as shown by Wood, McINISH and ORD (1985), as well as a negative correlation between the number of trades and the bid-ask spread.

The main contribution in this study is four fold. First, we find U-shaped intraday seasonality patterns in the onshore CNY market that is similar to stock markets, but could not confirm similar patterns in the offshore CNH market as presented by Ito and Hashimoto (2006). Second, there exist strong correlations between return volatilities and quote ratios for both the CNY and CNH. Third, we confirm quotes from New York and European countries at midnight when exchanges in Asian countries, including China and Hong Kong, are not open for business. Of particular interest is the way quotes are placed by the Bank of China (Hong Kong). The Bank of China (Hong Kong) placed a large number of quotes at midnight on only two days, both of which are characterized by the occurrence of global financial events. Lastly, quotes in the CNH market are less than those in the CNY market during normal market conditions, but sometimes sharply increase. This suggests that the CNH market is complementarily used during periods of financial stress involving liquidity shortages.

The remainder of this paper is organized as follows. The next section introduces the data processing procedure for intraday seasonality analysis, along with descriptive statistics of the data. Section 3 presents intraday trade patterns in the CNY and CNH markets. The final section provides a conclusion.

2. Data

2.1 Thomson Reuters Tick Data

Empirical studies of high frequency exchange rate data mainly use either (both) EBS data provided by ICAP or (and) Thompson Reuters Data. There are two kinds of quote data, “indicative quote” and “firm quote” data. An indicative quote is generally not the actual trading price and only a rate proposed to traders; trading is conducted after traders actually negotiate a trading price and volume. On the other hand, a firm quote is the actual trading price.

In this study, we obtain indicative quote data for the spot exchange rate, RMB/ US dollar in the CNY FX market and CNH FX market, from Thomson Reuters Tick History (TRTH). Despite the indicative quote, the reason for selecting the TRTH is that CNY FX rate data is not available from EBS. We need to compare the RMB between the CNY market and CNH market. Furthermore, to obtain an order quote without an intention to trade is prohibited in the CNY market.

The TRTH records all transaction data over a 24-hour period for all calendar days and each transaction contains a bid quote, ask quote, and the names of the financial institution posting the price order through the Thomson Reuters Dealing System.

2.2 Data Processing Procedure

The sample period is from February 21, 2011 to March 31, 2012. Raw bid and ask quotes recorded by the TRTH are not at even time intervals. This means that raw quotes are concentrated in business hours and are less present in non-business hours. We firstly generate second-by-second data from the raw data of both the CNY market and the CNH market¹. Next, we omit Saturdays, Sundays and days on which one of six markets is closed for national holidays from the second-by-second data. The six markets are markets that seem to have a strong relationship with the Chinese economy, and are China, Japan, Singapore,

¹ The prices are succeeded to until next quote. When different prices arise at the same time, the mean is used.

Taiwan, United States (New York), and United Kingdom (London)². Third, we extract ordered quotes of all zero second at minute t from second-by-second data. Moreover, we calculate the mean of the bid and ask quote (i.e. middle-quote) and create a bid-ask spread every t minute³. The differences in the log of the middle quotes between at minute t and at minute $t-1$ are defined as one-minute returns. Forth, one-minute returns are averaged over 15-minute intervals. We obtain a variation of returns, which is used as the volatility of each 15-minute interval, using 14 absolute values derived from the difference between the one-minute return and mean of the one-minute return at minute t . Additionally, we calculate the mean of the one-minute bid-ask spread for each 15-minute interval. Last, only quote ratios are estimated differently, where the sum of the raw quotes in a 15-minute interval are divided by total raw quotes in a 24-hour period.

To summarize, we prepare 96(=24*4) bid-ask spreads, mid-quotes, the ratio of quotes, volatilities, and returns for each day in the sample period to analyze the characteristics of average trading day in CNY market and CNH market.

2.3 Descriptive statistics of spread, volatility and the number of quotes

Wood et al. (1985) study stock return, trading volume, price changes and trading interval of trading of NYSE high frequency data from September 1971 to February 1972 and for 1982. They show that both return and risk (standard deviation of return) for stock prices on the NYSE is highest for 30 minutes from opening time and at the close of the day. Admati and Pfleiderer (1988) propose a theoretical microstructure model to explain why trading is concentrated at certain times. They suggest that because a trader executes orders from uninformed customers outside of the trading time, trading is the most active right after the opening and right before the closing of the market.

In general, the time stock markets open and close around the world are determined by particular rules. In contrast, the foreign exchange market is open for 24-hour trading because a market is always open somewhere in world. Therefore, intra-day seasonality of exchange rates may be different from that of stock prices. Ito and Hashimoto (2006) analyze

² Drop of weekend and holiday is taken account into time difference of six countries.

³ Bid-ask quote is made by ask spread minus bid spread.

characteristics of the frequency of price changes, changes rate of price, trading volume and bid-ask spread using EBS one-minute data of both the Japanese Yen / US dollar and Euro / US dollar. They find that there is double U shaped distribution brought about by participants in the London and Tokyo markets when examining trading volume against frequency quote changes, and a negative correlation between the number of trades and the bid-ask spread by carefully examining the London trading hour, New York trading hour, and Tokyo trading hour.

A breakdown of quotes shows that 77% of quotes from Shanghai and 22% from mainland China except for Shanghai in the strictly restricted CNY onshore market, but 58% of quotes from Hong Kong, 19% from FX trader companies in European countries and 15% from Singapore in the CNH offshore market in sample period.

Table 1 and 2 show descriptive statistics of bid-ask spread, volatility (absolute value of return average) and the number of quotes in CNY and CNH⁴. The tables indicate that the average number of quotes for one day 1091 in CNY and 542 in CNH in sample period. Shortly, the market size of CNY is more than twice the size of the CNH market. The kurtosis of the quote is different between CNY and CNH and quote is averagely ordered every day in CNY which is based on real trade but extreme number of quotes rarely happen in CNH which free capital movement is permitted. This means that financial turmoil occurring somewhere in the world is only easily transmitted to the CNH market, as Maziad and Kang (2012) suggest.

Volatility of the CNH market is more than twice that of the CNY market, as is to be expected,⁵ and the bid-ask spread of CNH is four times more than that of CNY. In short, the CNY market is more stable and has higher liquidity, while the CNH market is more risky and costly because volatility is a standard measure of market risk and a wider bid-ask spread (which means transaction fee in FX market) means lower liquidity.

⁴ Ito and Hashimoto (2006) find existence of US traders and UK traders by dividing the sample into Daylight Saving (summer) time and Standard (winter) time. In this study, we try to analyze data divided by summer time and winter time, but the following results do not change.

⁵ The hypothesis that mean of volatility of CNH is equal to that of volatility of CNY is rejected at significant level 1% by Welch's T test.

Table1: Descriptive Statistics of CNY Market

	Bid-ask spread	Volatility	Quote
Average	0.001	7.4581E-06	1091.424
Maximum	0.010	0.006	2375
Minimum	0.000	0.000	1
Median	0.001	0.000	1126
Mode	0.001	0.000	3
Standard deviation	0.001	5.E-05	543.786
Skewness	2.593	41.353	-0.195
Kurtosis	11.625	3264.021	2.399
Sample size	299011		

Table 2: Descriptive Statistics of CNH Market

	Bid-ask spread	Volatility	Quote
Average	0.004	1.81E-05	542.629
Maximum	0.030	0.008	1939
Minimum	0.000	0.000	1
Median	0.003	0.000	433
Mode	0.003	0.000	2
Standard deviation	0.003	1.E-04	459.182
Skewness	3.218	18.121	1.089
Kurtosis	22.009	789.140	3.611
Sample size	299034		

3. Intraday Seasonality Analysis in CNY and CNH

3.1 Quote Ratio

In the CNY market, daily central parity is announced at 9:15 (GMT 1:15) by the Chinese monetary authority and trading begins at 9:30(GMT 1:30). As illustrated in Figure 1 and Figure 2, the quote ratio sharply increases at 9:30. Since the CNY market is closed at 16:30(GMT 8:30), the quote ratio sharply decreases. This pattern is similar to the stock market, as shown by Wood et al. (1985). Additionally, a decreasing quote ratio is observed from 12:00(GMT 4:00) to 13:00(GMT 5:00). This is referred to as Lunch Time in the CNY market.

The peaks of quote ratio in the morning session in the CNH market are confirmed in Figure 2. Figure 2 shows the quote ratio sharply increases by about 3-4% from 9:15 (GMT1:15), after gradually increasing from 8:00 (GMT0:00). 8:00 (GMT0:00) in China is 9:00 in Japan, which is when the Japanese stock market opens. That is, the CNH market is superior to the CNY market because in the CNH market, we are able to incorporate news generated in Japan and the other countries more quickly than in the CNY market into the price. A breakdown of financial institutions placing quotes from 8:00 to 9:00 China time shows 23% coming from European FX brokers (Switzerland), 18% from the Bank of China (Hong Kong), 15% from the Singapore branch of European financial banks and HSBS Hong Kong. The CNH market also seems to have lunch time, at GMT4:00 to 5:00. CNH is gradually closing from Chinese time 17:30 (GMT 9:30, Japanese time 18:30).

The characteristics of the quote ratio around the closing time is different between CNY and CNH. The quote ratio at closing time in the CNY market increases quite sharply and accounts for about 6% of all quotes in a day. Meanwhile, such a surge is not observed in the CNH market. We could interpret the surge observed in the CNY market as finishing today's trade settlement at the end of day, and quotes in CNH market depend on random news events.

Figure 1 and 2 indicates small peaks in the quote ratio in both the CNY and CNH at midnight in China and other Asian countries (GMT 16:00 and 21:45). This accounts for a 1-3% increase. The midnight quote ratio from GMT15:00 to 24:00 is quite negligible. It accounts

for about 6-7% of all quotes in a day, which is equivalent to 734 quotes in CNY and 1924 quotes throughout the sample period. These quotes consist of 33% from the Bank of China (Hong-Kong), 31% from Shanghai, 8% from New York in CNY market, and 50% from Hong Kong (eight banks except for Bank of China (Hong Kong)), 15% from New York, 20% from European countries and 7% from Singapore. That is, there are midnight quotes from countries other than China in both markets (regardless CNY is closed) and there are especially a lot of midnight quotes in the CNH market.

The Bank of China (Hong Kong) plays a large role in both the CNY and CNH markets. The Bank of China (Hong Kong) is the only bank with a *clearing* function for RMB trades. Midnight quotes by the Bank of China (Hong Kong) intensified on specific days: March 23, 2011 (Wed) in the CNY market, and March 23, 2011 (Wed) and September 28, 2011 (Wed) in the CNH market. Cheung and Rime (2014) identified September 21, 2011 (Wed) as a breaking point that was marked by the beginning of a turbulent period in which the CNH displayed an unusually high discount to the CNY. Since the CNY exchange rate was affected by the lagged CNH exchange rate return rate only after September 21, 2011 in the subsample period during their study, huge trading volume by the Bank of China (Hong Kong) in the CNH market could possibly be interpreted as an attempt to forestall the impact on the CNY market during a period of liquidity stress as risk-off trades are likely to start with the CNH first, as the authors noted.

Other noteworthy events around March 23, 2011 and September 28, 2011 are as follows. It was announced that the G7 would coordinate interventions targeting the Japanese Yen on March 18, 2011 to calm market turmoil after the Great East Japan Earthquake and to alleviate default concerns over Portugal's government debt. In addition, the RMB was recorded at the highest level against the US dollar at that time in the Shanghai market because inflation has been a concern in China. On September 23, 2011, an emergency statement in terms of European Sovereign debt problems was reported at a meeting among G20 central bank finance ministers and governors, and news reports on 28 September said that the EU committee would introduce a Tobin tax on stocks and bonds trades from 2014. The Bank of China (Hong Kong) could have possibly placed a quote at midnight on the days mentioned earlier in response of these events, although we do not know the true reason why it placed midnight quotes, especially in the CNY market, which had no counterparty at that time.

However, accounting for the role of Bank of China (Hong Kong) in both RMB markets, its midnight quote before opening time might indicate Chinese government's RMB direction after opening time.

Figure 1: Intraday Seasonality in CNY Market

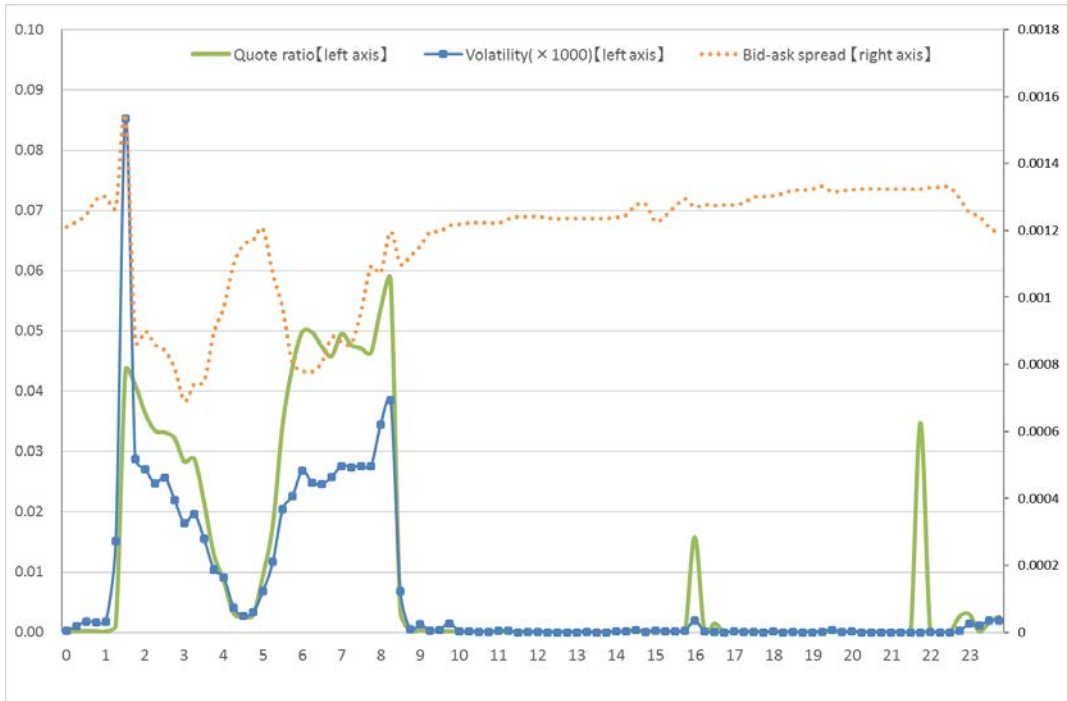
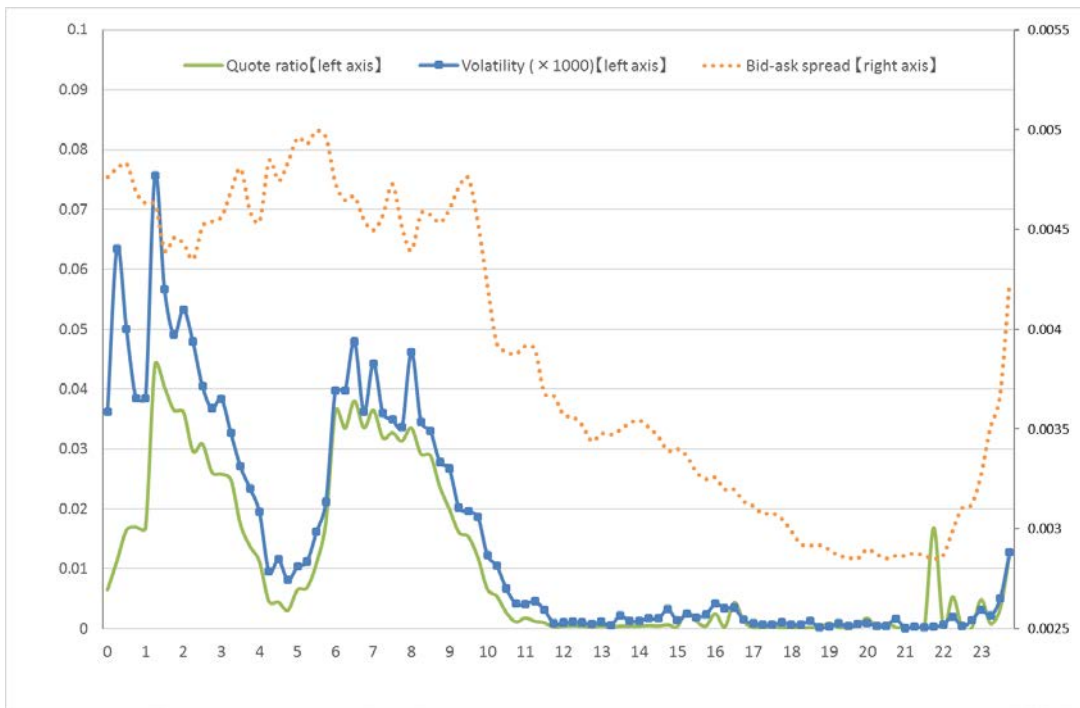


Figure2 Intraday seasonality in CNH Market



3.2 Volatility

Intraday variation of volatility is the largest at the opening time (GMT1:30) in the CNY market. It can be caused by the following reasons. One is that the PBOC announces central parity at 9:15 (GMT1:15) China time. Second, world news that occurred during the night is incorporated into the price at that time. Except for the opening time 9:30, the CNY market is very stable and its volatility is less than $0.03E-03$ (absolute value of change rate).

In the CNH market, volatility sharply increases between 8:15 (GMT0:15) and 9:15 (GMT1:15), which is consistent with a surge in the quote ratio. Although it is difficult to conclude that participants in the CNH market are influenced by movements of the Japanese stock market, the Japanese stock market is opened at GMT0:00. Our data shows that financial institutions in European countries, Hong Kong and Singapore move on ahead. A surge of volatility at 9:15 (GMT1:15) results only from an announcement of central parity by PBOC.

3.3 Bid-Ask Spread

The characteristics of bid-ask spread is different between the CNY and CNH markets. Figure 1 show that the spread is wider at opening time 9:30 (GMT1:30), lunch time and closing time 16:30 (GMT8:30) during trading hours on the CNY market, but is narrow during other time zones. In contrast, the spread is wider at non-active trading times after Chinese time 18:00 (GMT10:00) along with at opening time, lunch time and closing time in CNH market. In general, preceding studies indicate that when trading is active and there is sustained fierce competition among traders, the spread is narrow and vice versa. Because the bid-ask spread is interpreted as a transaction cost. The reasons for this different midnight feature of the CNH market might be the result of the indicative quote and market system. The indicative quote is only a proposed price and the actual price is then negotiated among traders. That is, the indicative quote is different from the actual trading price (firm quote is actual trading price). The CNY market adopts a Market Maker system, but the CNH market does not. The market maker system in the CNY market prohibits the placing of bid and ask quotes that are far from

the actual price at which the trade is executed. This means that while the indicative quote in CNY market is close to firm quote, quotes in the CNH market may be just submitted to only look for a counterparty.

3.4 Correlation among Quote Ratio, Volatility and Bid-Ask Spread

Table 3 shows correlation coefficients among the quote ratio, volatility and bid-ask spread at business time (GMT+8:30 – 1:30), business time without opening time, and business time without opening time and lunch time in the CNY market. Table 4 shows the same information for the CNH market. The results of these tables are summarized as follows. First, right after the markets open, the spread and volatility are positively correlated only in the CNY market. However, except for opening time, the correlation between the spread and volatility is negative. In other words, the wider spread is, the smaller is volatility. This tendency is pronounced in the CNH market. Second, the negative correlation between the quote ratio and the spread is observed in both markets. It is also pronounced in CNH. Third, in both markets, the correlation between the quote and volatility is strongly positive. That is, as the number of quotes increases, volatility becomes larger. The above results are perfectly consistent with Ito and Hashimoto (2006), which studied intraday seasonality in yen/ dollar and euro/dollar markets, but inconsistent with the results of Wood et al. (1985). Namely, our result regarding the RMB market is supportive of Ito and Hashimoto's (2006) insistence on the distinctive nature of the exchange rate market, and the negative correlation between the spreads and the number of trades.

Clark (1973) points out that high frequent volatility of asset prices depend on news arrival, and when traders get new information, trading is active and variation of price is fast and vice versa. This is known as the Mixture-of-Distribution Hypothesis(MDH). The results of our study are consistent with MDH in the CNY and CNH markets, and show a definitive, positive correlation between trading volume (number of quotes here) and volatility.

Table3 Coefficient Matrix in CNY Market

(1) 1:30 to 8:30 (GMT)

	Quote ratio	Bid-ask spread	Volatility
Quote ratio	1.000		
Bid-ask spread	-0.191	1.000	
Volatility	0.676 ***	0.338 *	1.000

*** : 1% significant level, ** : 5% significant level, * : 10% significant level

(2) 2:00 to 8:30 (GMT)

	Quote ratio	Bid-ask spread	Volatility
Quote ratio	1.000		
Bid-ask spread	-0.330 *	1.000	
Volatility	0.963 ***	-0.289	1.000

*** : 1% significant level, ** : 5% significant level, * : 10% significant level

(3) 2:00 to 4:00 and 5:00 to 8:30(GMT)

(Excludes first 30 after market opens and lunch break)

	Quote ratio	Bid-ask spread	Volatility
Quote ratio	1.000		
Bid-ask spread	-0.167	1.000	
Volatility	0.924 ***	-0.141	1.000

*** : 1% significant level, ** : 5% significant level, * : 10% significant level

Table 4 Coefficient Matrix in CNH Market

(1) 1:30 to 8:30 (GMT)

	Quote ratio	Bid-ask spread	Volatility
Quote ratio	1.000		
Bid-ask spread	-0.704 ***	1.000	
Volatility	0.954 ***	-0.805 ***	1.000

*** : 1% significant level, ** : 5% significant level, * : 10% significant level

(2) 2:00 to 8:30 (GMT)

	Quote ratio	Bid-ask spread	Volatility
Quote ratio	1.000		
Bid-ask spread	-0.668 ***	1.000	
Volatility	0.951 ***	-0.777 ***	1.000

*** : 1% significant level, ** : 5% significant level, * : 10% significant level

(3) 2:00 to 4:00 and 5:00 to 8:30(GMT)

(Excludes first 30 after market opens and lunch break)

	Quote ratio	Bid-ask spread	Volatility
Quote ratio	1.000		
Bid-ask spread	-0.718 ***	1.000	
Volatility	0.923 ***	-0.840 ***	1.000

*** : 1% significant level, ** : 5% significant level, * : 10% significant level

4. Conclusion

CNY is the onshore market for the RMB, and its trade is restricted to only domestic residents that can document actual trading demand. Furthermore, the CNY market has adopted a Managed float system (crawling-like-arrangement). Thus central parity is announced every morning and RMB is controlled within a pre-determined band. On the other hand, the CNH offshore market has adopted a free float system and has relatively weak restrictions.

This paper examined market activity in these two different markets for the RMB using high frequency data. The main findings of this study are as follows.

First, CNY market is two times larger than the CNH market in terms of the number of average quotes. For the bid-ask spread, the CNH is four or five times wider than CNY. This evidence suggests that the CNY market is central in RMB trading and that the CNH is still a low liquidity market with trading high cost. However, the CNH market becomes much more active in periods of financial turmoil so that it might be used as the RMB's second complementary market. For CNY and CNH quote ratios, we find little difference in business time, but CNH is opened more ahead than CNY. Moreover, quotes sharply increase right before closing time in the CNY market, but quotes in the CNH gradually decreasing before and after closing time.

Second, this study reveals that the level of quotes at midnight Asian time is not negligible. Despite prohibited trading in the CNY market, quotes are confirmed from Shanghai, Hong Kong and New York. In the CNH market, 40% of midnight quotes are from New York, European countries and Singapore. In particular, the way the Bank of China (Hong Kong) places quotes is quite interesting. The Bank of China (Hong Kong) places an intensively large amount of quotes on specific days in CNY and only on two days in the CNH market during the sample period. It is impossible to be certain of the reasons for these actions, but taking into consideration the dates on which the quotes were placed, it seems that the Bank of China (Hong Kong) is sending certain signals to traders given that news events destabilized global financial markets on every date on which it placed a significantly large amount of quotes.

Third, this study shows intraday correlation coefficients among quote ratios, volatility and spreads. As a result, correlation between spreads and volatility is positive within one hour from opening time only in CNY, but after that, the correlation is completely negative. This is consistent with Ito and Hashimoto (2006) which examined the yen/dollar and euro/dollar exchange rate market, known as the largest liquidity market in the world. One of contributions of this study is to collect evidence that the correlation between trading volume (the number of quote) and volatility is strongly negative even in the low liquidity CNH market.

References

Admati, A. R. & Pfleiderer, P. (1988). Theory of Intraday Patterns: Volume and Price Variability. *Review of Financial Studies*, 1(1), 3-40.

Ding, D. K., Tse, Y. & Williams, M. R. (2014). The Price Discovery Puzzle in Off-shore Yuan Trading: Different Contributions for Different Contracts. *Journal of Futures Markets*, 34(2), 103–123.

Ito, T. & Hashimoto, Y. (2006). Intraday Seasonality in Activities of the Foreign Exchange Markets: Evidence from the Electronic Broking System. *Journal of Japanese International of Economies*, 20, 637-664.

Wood, Robert, A., McINISH, T. H. & ORD, K. J. (1985). An Investigation of Transaction Data for NYSE Stock. *the Journal of Finance*, 40(3), 723-741.

Maziad, S. & Kang, J. S. (2012). RMB Internationalization: Onshore/Offshore Links. *IMF Working Paper*, WP12/133.

Cheung, Y. W. & Rime, D. (2014). Offshore Renminbi Exchange Rate: Microstructure and Links to the Onshore Market. *Journal of International Money and Finance*, 49, 170-189.