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China's exchange rate regimes revisited and bubble detection in 2005-2015

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Abstract: The International Monetary Fund's decision in 2015 to add the Renminbi to its Special Drawing Rights currency basket has in effect granted the Chinese Yuan the international reserve currency status. This study revisits China's five exchange rate regimes in 2005-2015 and investigates the relationships among the currencies of the Chinese Yuan, the U.S. Dollar and the Euro. The Log-Periodic Power Law Singularity model is proposed as a generic parameterization to capture the super-exponential behavior in the tetrad of exchange rates of these currency pairs. The transient non-sustainable faster-than-exponential acceleration of the "CNY against USD" from August 2005 to July 2008 suggests the existence of an apparent bubble with an under-valuation. The clustered signals of LPPLS Confidence indicators for the "CNY against USD" from May 2011 to March 2012 suggest the termination of its long-term growth. The signals for the "EUR against USD" and "CNY against EUR" emerging from January 2014 to August 2015 show a tightly coupled relationship among these currency pairs. Moreover, the empirical estimates of the most possible critical time by the standard Ordinary Least Squares method and the Quantile Regression method for the time series of "CNY against USD" tends to be later than that of "CNY against EUR" in the five regimes.

Key words: Exchange rate regime, log-periodic power law singularity, bubble

I. INTRODUCTION

As the world's second largest economy, China has been a participant, facilitator and contributor in the international community. The economic stimulus package and the purse of a "reform and open-door" policy in 1978helped China to become the world's biggest exporter of industrial products. However, this also created a strong connection with the external economic crises when it highly depends on external demand. Since the 1990s cycle of record capital flows to the emerging markets was followed by widespread crises, exchange rate regimes have been the primary concerns of international economists and policy-makers.

China moved to a managed floating regime against a basket of currencies in July 2005. As revealed in a speech on August 10, 2005 by the governor of the People's Bank of China (PBoC) Xiaochuan Zhou, the major currencies contained in the basketwere the U.S. Dollar (USD), the Japanese Yen (JPY), the Euro (EUR) and the South Korean Won (KRW). Other minor currencies included the Australian Dollar (AUD), the Canadian Dollar (CAD), the British Pounds (GBP), the Malaysian Ringgit (MYR), the Russian Ruble (RUR), the Singapore Dollar (SGD),and the Thai Baht (THB) [1]. Several researchers have since attempted to estimate the weights attached to Chinesecurrency (CNY) in the basket, and confirmed that the CNY was in fact tightly coupled to the USD from 2005 to2010 [2]. More specifically, the currency basket was dominated by the USD in the first few months of the de juremanaged floating period [3]. After February 2006, the weights in the basket modestly but steadily transferred fromthe USD to a few non-USD currencies [4]. By mid-2007, it switched a substantial part of weight in the USD into the EUR [5]. By using a statistical test in analogy to the Ljung-Box test, the cross-correlations significantly existed in CNY-USD, CNY-EUR, CNY-JPY, and CNY-KRW from July 21, 2005 to May 25, 2012, where the currency weight was arranged in the order of USD>EUR>JPY>KRW [6]. As such, most studies on the China's exchange rate regimes were investigating whether the Chinese Yuan was moving away from the long-standing U.S. Dollar peg. Besides, most estimation strategy for understanding the de facto exchange rate regime was a linear regression model based on cross-currency exchange rates[4], lacking of a framework for a diagnosis of its structural change.

Over the past decade, CNY has increased in value dramatically along with the USD. This phenomenon increases the importance of the study in the context of currency because frequent occurrence of bubbles and crashes lead to deviation from the main value of exchange rate. In 1987 empirical researches have largely concentrated on testing for explosive trends in the foreign exchange rates of the U.S. Dollar versus the currencies of Germany, France, Canada and Japan [7-8]. Within the scope of econophysics, bubbles and crashes in the Turkish Lira/U.S. Dollar, the Turkish Lira/Euro, the Turkish Lira/Japanese Yen and the Turkish Lira/Swiss Franc exchange rates were detected in the global economic crisis from January 1, 2005 to December 20, 2013 [9]. Strong evidence of explosive behavior in the nominal CNY/USD exchange rate was found during2005-2006 and in 2008 by employing the generalized sup ADF (GSADF) unit root tests into the analysis. Besides,there was no bubble before 2005 for its fixed exchange rate regime and the bubble in 2008 was determined by the relative prices of traded goods [10]. Due to the strongest impact of the recently boom and burst of financial bubble in China's stock market in June 2015 [11], China is facing the growing pressure from the sharp decline in its foreign trade and foreign direct investment inflows. More broadly, any bubble emanating from one country might spill over to another either simultaneously or with a time lag, and probably induce collapses on more than one market.

This study thus revisits China's five exchange rate regimes in 2005-2015 and investigates the relationships among the currencies of the Chinese Yuan (CNY), the U.S. Dollar (USD) and the Euro (EUR). The Log-Periodic Power Law Singularity model [12-14] is proposed as a generic parameterization to capture the super-exponential behavior in the tetrad of exchange rates of these currency pairs. The standard Ordinary Least Squares method and Quantile Regression method are applied to explicitly explore the changes of parameters within different regimes.

The remainder of this paper is organized as follows. Section 2 divides the de facto exchange rate regime of China into five periods. Section 3 presents the LPPLS model and the calibration methods. Section 4 introduces the data, and section 5 presents the empirical results. Section 6 concludes.

II. CHINA'S HISTORICAL EXCHANGE RATE REGIMES IN 2005-2015

The currency of People's Republic of China, Renminbi (RMB), has experienced significant adjustments due to economic and political reasons upon its establishment. We investigate five periods corresponding to five exchange rate regimes after China gave up on a fixed exchange rate to U.S. Dollar in 2005. The periods are divided mainly according to the policies announced by the People's Bank of China (PBoC).

A. Regime 1: July 2005-July 2008

In July 2005, PBoC officially announced a switch to a new exchange rate regime that the exchange rate would become adjustable, based on market supply and demand with reference to a basket of currencies, with numerical weights unannounced, allowing a fluctuation by up to 0.3% around the central parity rate.

The switch at this time was from the single dollar-peg monetary policy to a managed floating exchange rate system, where market forces determined the general direction of the movement, but the government retarded its rate of appreciation through market intervention.

B. Regime 2: July 2008- June 2010

China halted its currency appreciation policy around mid-July 2008. In response to the global financial crisis, Chinese government returned to the fixed RMB-dollar peg, and the CNY/USD exchange rate was held relatively constant at 6.83 through around mid-June 2010.

C. Regime 3: June 2010-April 2012

On June 19, 2010, based on current economic conditions, PBoC decided to proceed further with reform of theRMB exchange rate regime and to enhance the exchange rate flexibility. The CNY/USD exchange rate at this time has gone up and down since RMB appreciation was resumed, but it has appreciated overall.

D. Regime 4: April 2012-March 2014

In April 2012, the currency's daily trading band for the CNY/USD was extended to 1% from 0.5%. The situation at this time is letting market forces play a bigger role in determining the value of the RMB, as a further step in liberalizing exchange rate.

E. Regime 5: March 2014-October 2015

PBoC widened the trading band for the RMB exchange rate from 1% to 2% on March 17, 2014. On August11, 2015, the PBoC announced a policy of setting the midpoint rate of the CNY/USD, the benchmark for market transactions, at 6.2298, 1.8% weaker than the previous day, and using the previous day's closing market rate as a reference. The situation at this time can be regarded as a major step in shifting from the current managed floating exchange rate system to a free floating exchange rate system.

Generally speaking, five exchange rate regimes of China in 2005-2015 can be summarized as Table 1.

Table 1: Five exchange rate regimes of China in 2005-2015.

Period	Exchange rate regime
July 2005–July 2008	Crawling peg to basket, managed floating system.
July 2008–June 2010	Fixed exchange rate relaunched.
June 2010–April 2012	Slight upward crawling peg, managed floating system.
April 2012–March 2014	More flexible managed floating system.
March 2014–October 2015	New midpoint rate determination mechanism,more market-determined managed floating system.

III. LOG-PERIODIC POWER LAW SINGULARITY MODEL

The Johansen-Ledoit-Sornette (JLS) model [12-13] assumes that the asset price $p(t)$ follows a standard diffusive dynamics with varying drift $\mu(t)$ in the presence of discretediscontinuous jumps,

$$\frac{dp}{p} = \mu(t)dt + \sigma(t)dW - \kappa dj, \quad (1)$$

where $\sigma(t)$is the volatility and dW is the increment of a Wiener process (with zero mean and variance equal to dt).The term dj represents a discontinuous jump such that$j$=0 before the crash and$j$=1 after the crash occurs.The loss amplitude associated with the occurrence of a crash is determined by the parameter κ. Each successivecrash corresponds to a jump of $j$by one unit. The dynamics of the jumps is governed by a crash hazard rate $h(t)$.Since $h(t)dt$ is the probability that the crash occurs between$t$ and $t+dt$ conditional on the fact that it has not yethappened, we therefore have the expectation$E_t[dj] = 1 \times h(t)dt + 0 \times (1-h(t))dt = h(t)dt$. By the no-arbitragecondition leading to the condition that the price process is a martingale ($E_t\left[\frac{dp}{p}\right] = 0$, neglecting the risk free rate), it leads to$\mu(t) = \kappa h(t)$.

Under the assumption of the JLS model, the crash hazard rate aggregated by the noise traders with herding behaviors has the following dynamics:

$h(t) \approx B_0|t_c - t|^m + B_1|t_c - t|^m cos(\omega ln|t_c - t| + \varphi_0)$.(2)

Using $\mu(t) = \kappa h(t)$, we obtain the dynamics of the expectation of the logarithm of the price in the form of the Log-Periodic Power Law Singularity (LPPLS) model:

$E[lnp(t)] = A + B|t_c - t|^m + C|t_c - t|^m cos(\omega ln|t_c - t| + \varphi)$,(3)

where$t_c$denotes the most probable time for the burst of the bubble, in the form of a crash for example. The constant$A = ln[p(t_c)]$gives the terminal log-price at the critical timet_c. $B$and C respectively control the amplitude of the power law acceleration and of the log-periodic oscillations. The exponent m quantifies the degree of super-exponential growth. The log-periodic angular frequency ω is related to a scaling ratio $\lambda = e^{\frac{2\pi}{\omega}}$of the temporalhierarchy of accelerating oscillations converging to t_c. Finally, $\varphi \in (0,2\pi)$ is a phase embodying a characteristictime scale of the oscillations. Expression (3) is the first-order log-periodic correction to a pure power law for an observable exhibiting a singularity at t_c[14-15].

Previous calibrations of the LPPLS specification (3) to the log-price development during a number of historical financial bubbles have suggested to qualify fits based on the parameters of the LPPLS model belonging to the following intervals [16-18]: $m \in [0.1,0.9]$, $\omega \in [6,13]$, $|C| \leq 1$, B <0. Given the starting and ending dates$t_{start}$and $t_{end}$of the fitting window, $dt = t_{end} - t_{start}$ is defined as the duration of the fitting window. The criticaltime t_c is searched in the interval$[t_{end} - \eta dt, t_{end} + \eta dt]$, with$\eta$ typically equal to 0.20.

In our explorations, the standard Ordinary Least Squares (OLS) method [16] and the Quantile regression (QR) method [19] are applied to calibrate the LPPLS model with a tetrad of exchange rate time series $p_i(t), i = 1,2,3,4$, where

$E[lnp_i(t)] = A_i + B_i|t_{c_i} - t_i|^{m_i} + C_i|t_{c_i} - t_i|^{m_i} cos(\omega_i ln|t_{c_i} - t_i| + \varphi_i), i = 1,2,3,4$.(4)

Then we check the relationships among the parameters of$\{A_i, B_i, C_i, m_i, \omega_i, t_{c_i}, \varphi_i\}$ when the exchange rates satisfying $p_3(t) = p_1(t)p_2(t)$ and $\frac{1}{p_4(t)} = p_1(t)p_2(t)$, in absence of arbitrage and for perfect markets with no friction.

IV. DATA

As shown in Table 2, we have chosen four daily exchange rates for our study from August 22, 2005 to October30, 2015 among pairs of currencies: the Chinese Yuan (CNY), the U.S. Dollar (USD) and the Euro (EUR). It wouldbe easy to present the calibration results in the following section by multiplying each of them by a factor. For example, the time series named as "CNY per 10^4 USD" corresponds to the time series "CNY/USD" multiplied by10^4.

Table 2: List of four exchange rates. The data was obtained from Thomson Reuters Datastream.

Symbol of exchange rate	Data range
USD/CNY	August 22, 2005 to October 30, 2015
CNY/USD	August 22, 2005 to October 30, 2015
USD/EUR	August 22, 2005 to October 30, 2015
EUR/CNY	August 22, 2005 to October 30, 2015

V. EMPIRICAL RESULTS

To capture the changes of China's exchange rate regimes more formally, we calibrate the segmented time series within different fitting windows. As suggested by Table 1, we divide the whole sample into five periods: 2005.08.22-2008.07.07 (Regime 1); 2008.07.08-2010.06.18 (Regime 2); 2010.06.21-2012.04.13 (Regime 3); 2012.04.15-2014.01.24 (Regime 4) and 2014.01.27-2015.08.11 (Regime 5). Furthermore, four time series in Table 2 can be grouped as a tetrode of exchange rates, or a triple of currencies as represented in Figure 1.

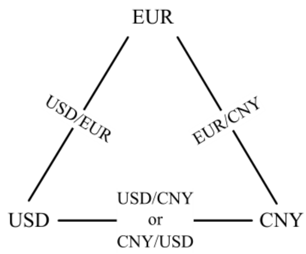


Figure 1: A triple of currencies: {EUR, USD, CNY}

A. Calibrations in five exchange rate regimes

For the five exchange rate regimes, the following tables exhibit the estimates of three nonlinear parameters(i.e.,m, ω, t_c) and the root-mean-square-error (RMSE) obtained by the standard Ordinary Least Squares (OLS)calibration method. Meanwhile, $\overline{t_c(q)}$ is the average of $\{t_c(q)|q$ =0.10, 0.20, ...,0.90} obtained by the Quantile regression method. The following figures not only give the red standard LPPLS fitting curve but also show a bundle of colored quantile-based fitting curves in the in-sample windows, which are also extended by the dashed out-of-sample predictions. The black dashed vertical line in each panel represents the corresponding end date $t_{end}$of the in-sample window.

1)Regime 1 revisited: For the first regime from August 22, 2005 to July 7, 2008, we find that: (a) As shown in Figure 2, the estimated$\overline{t_c(q)}$(USD per 10^4 CNY)=$\overline{t_c(q)}$(CNY per 10^4 USD)=2008.08.09 are very close to the $t_{end}=$ 2008.07.07, indicatingthat the most probable critical time of the transition is forthcoming. Besides, because USD/CNY and CNY/USDare the inverse of each other, the "USD per 10^4 CNY" and the "CNY per 10^4 USD" are visually symmetrical with respect to the horizontal line y=ln(10^4)=9.210. So the quantile-based fitting curve at q for "USD per 10^4 CNY"(first panel) is symmetrical with the quantile-based fitting curve at $1-q$ for "CNY per 10^4 USD" (second panel).(b) As shown in Table 3, for the triple of three currencies {EUR, USD, CNY}, although these time series satisfying(USD per 10^8 CNY) = (USD per 10^4 EUR)*(EUR per 10^4 CNY), the relationship among t_c(USD per 10^8 CNY),t_c(USD per 10^4 EUR), and t_c(EUR per 10^4 CNY) is uncertain but harboring t_c(USD per 10^8 CNY)$\neq$ t_c(USD per10^4 EUR)$\neq$ t_c(EUR per 10^4CNY). Moreover, we find that the estimated critical time of "USD per 10^8 CNY"obtained by two calibration methods are later than that of "EUR per 10^4 CNY". (c) As the fitting curves shown in the in-sample window in the first panel of Figure 2, the CNY appreciates against USD in the Regime 1. Given that the super exponential growth was not followed by a crash or correction (as the black dashed curve in the out-of-sample window), the growth is more correct to be interpreted as a catching up of the exchange rate towards the larger fundamental value of the RMB. In other words, this kind of "apparent bubble" in the Regime 1 is a delay of the market reaction to reflect the true value of the RMB.

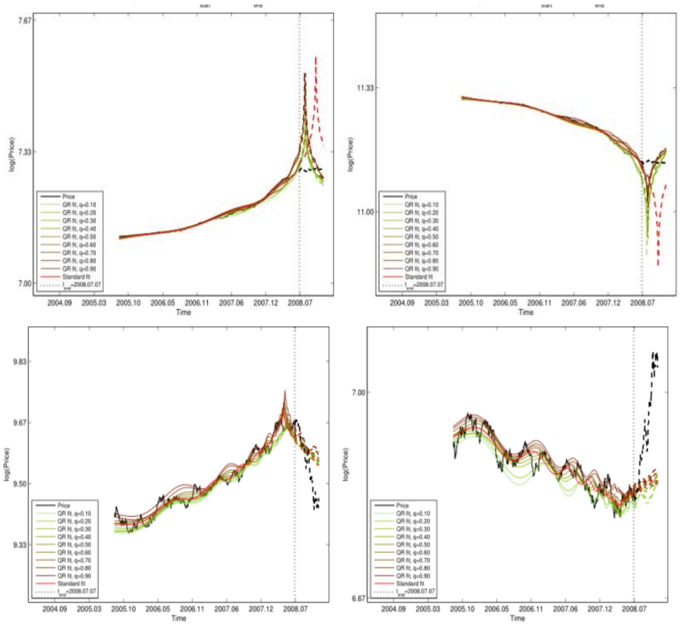


Figure 2: Red standard LPPLS fitting curve and quantile-based fitting curves at {q=0.10, 0.20, ..., 0.90} in Regime1 from August 22, 2005 to July 7, 2008 of: USD per 10^4 CNY (first panel), CNY per 10^4 USD (second panel), USDper 10^4 EUR (third panel), EUR per 10^4 CNY (fourth panel).

Table 3: Calibrations of 4 exchange rates in Regime 1 from 2005.08.22 to 2008.07.07.

Exchange rate	m	ω	t_c	$\overline{t_c(q)}$	RMSE
USD per 10^8 CNY	0.100	7.340	2008. 10.11	2008. 08.09	0.004
CNY per 10^4 USD	0.100	7.318	2008. 10.10	2008. 08.09	0.004
USDper1 0^4 EUR	0.510	13.000	2008. 05.01	2008. 05.13	0.016
EURper1 0^4 CNY	0.701	12.238	2008. 04.13	2008. 04.23	0.014

2)Regime 2 revisited: For the second regime from July 8, 2008 to June 18, 2010, as shown in Table 4, when the USD/CNY exchange rate is fixed, we have t_c(USD per 10^4 EUR)=t_c(EUR per 10^4 CNY). This can be regarded as a kind of "contagion effect" directly from the exchange rate "EUR against USD" to the "CNY against EUR". Besides, the fitting curve at q=0.10 of "USD per 10^4 EUR" (second panel in Figure 3) isalmost symmetrical with the fitting curve at q=0.90 of "EUR per 10^4 CNY" (third panel in Figure 3).

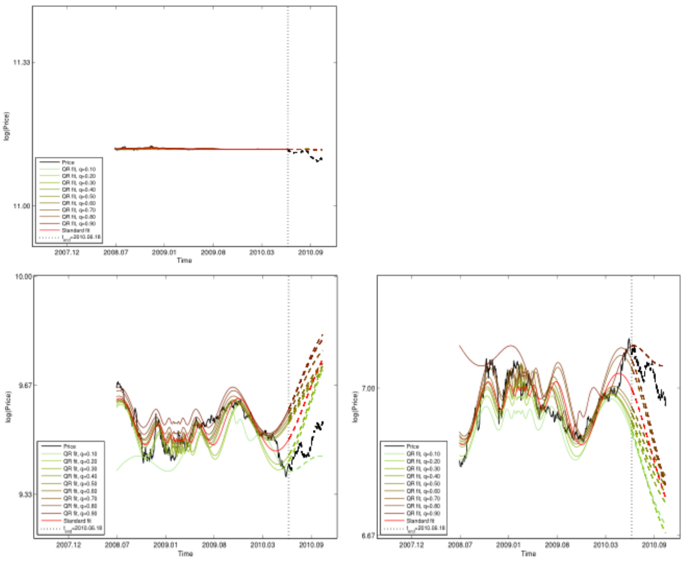


Figure 3: Red standard LPPLS fitting curve and colored quantile-based fitting curves at {q=0.10, 0.20, ..., 0.90}in Regime 2 from July 8, 2008 to June 18, 2010 of: CNY per 10^4 USD (first panel), USD per 10^4 EUR (second panel), EUR per 10^4 CNY (third panel).

Table 4: Calibrations of 4 exchange rates in Regime 2 from 2008.07.08 to 2010.06.18.

Exchange rate	m	ω	t_c	$\overline{t_c(q)}$	RMSE
USD per 10^8 CNY	0.100	7.499	2008. 12.04	2009. 06.20	0.001
CNY per 10^4 USD	0.100	7.501	2008. 12.04	2009. 06.21	0.001
USDper10 ^{4} EUR	0.900	6.000	2009. 03.23	2009. 04.09	0.039
EURper10 ^{4} CNY	0.900	6.000	2009. 03.23	2009. 04.10	0.038

3)Regime 3 revisited: For the third regime from June 21, 2010 to April 13, 2012, CNY steadily appreciates against USD in the first panel of Figure 4. For the triple of currencies {EUR, USD, CNY}, although the time seriessatisfying (USD per 10^8 CNY)=(USD per 10^4 EUR)*(EUR per 10^4 CNY), we have t_c(USD per 10^8 CNY)>t_c(USD per 10^4 EUR)>t_c(EUR per 10^4 CNY) in Table 5.

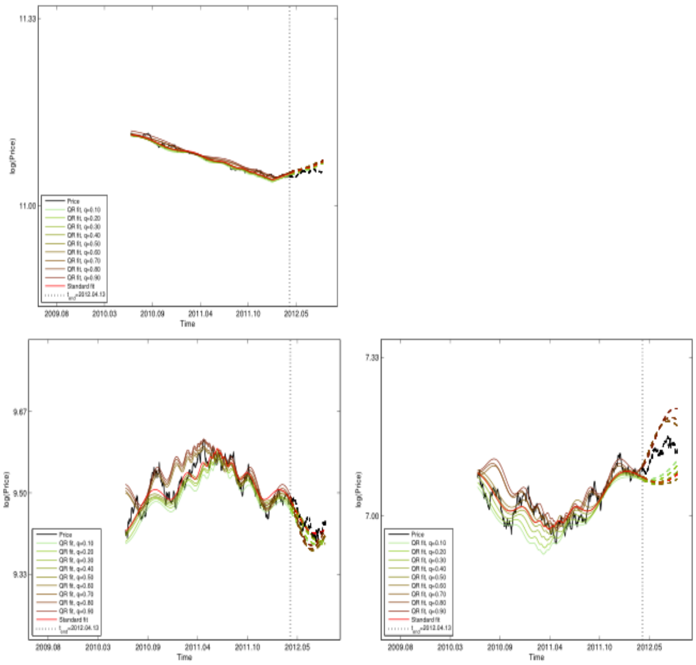


Figure 4: Red standard LPPLS fitting curve and colored quantile-based fitting curves at $\{q=0.10, 0.20, ..., 0.90\}$ in Regime 3 from June 21, 2010 to April 13, 2012 of: CNY per 10^4 USD (first panel), USD per 10^4 EUR (second panel), EUR per 10^4 CNY (third panel).

Table 5: Calibrations of 4 exchange rates in Regime 3 from 2010.06.21 to 2012.04.13.

Exchange rate	m	ω	t_c	$\overline{t_c(q)}$	RMSE
USD per 10^8 CNY	0.900	12.867	2012. 02.05	2012. 02.03	0.003
CNY per 10^4 USD	0.900	12.874	2012. 02.05	2012. 02.04	0.003
USDper1 0^4 EUR	0.669	8.530	2011. 06.25	2011. 06.02	0.020
EURper1 0^4 CNY	0.900	6.000	2011. 04.03	2011. 04.09	0.022

4)Regime 4 revisited: For the fourth regime from April 15, 2012 to January 24, 2014, as shown in Table 6 and Figure 5, these fits confirm the intrinsic nonlinear relationships oft_c(USD per 10^8 CNY)>t_c(USD per 10^4 EUR) as well as $t_c(q)$(USDper 10^8 CNY)>$t_c(q)$(USD per 10^4 EUR), as found in the Regime 1, Regime 2 and Regime 3.

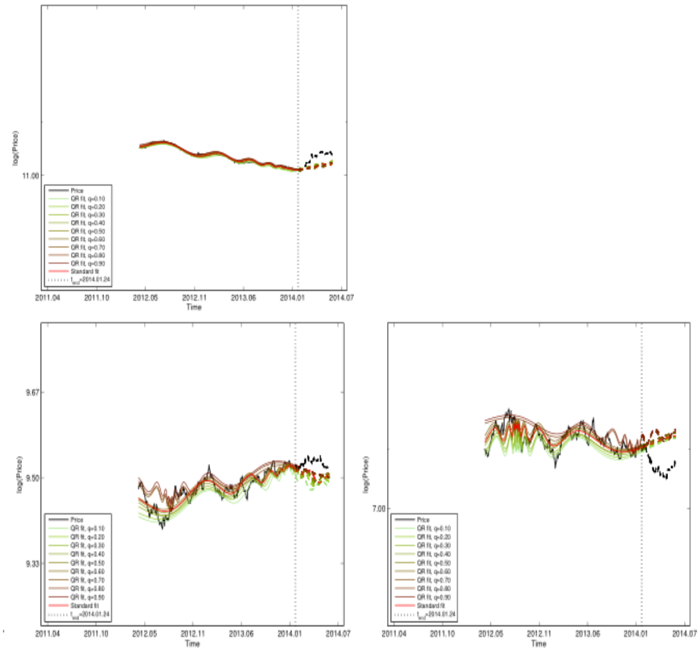
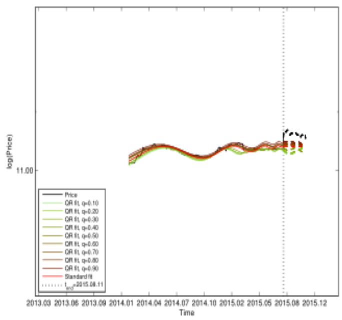


Figure 5: Red standard LPPLS fitting curve and colored quantile-based fitting curves at $\{q=0.10, 0.20, ..., 0.90\}$ in Regime 4 from April 15, 2012 to January 24, 2014 of: CNY per 10^4 USD (first panel), USD per 10^4 EUR (second panel), EUR per 10^4 CNY (third panel).

Table 6: Calibrations of 4 exchange rates in Regime 4 from 2012.04.15 to 2014.01.24.

Exchange rate	m	ω	t_c	$\overline{t_c(q)}$	RMSE
USD per 10^8 CNY	0.900	11.805	2014. 01.13	2014. 01.13	0.002
CNY per 10^4 USD	0.900	11.809	2014. 01.13	2014. 01.16	0.002
USDper1 0^4 EUR	0.634	8.511	2014. 01.03	2013. 07.16	0.015
EURper1 0^4 CNY	0.162	6.000	2012. 08.25	2012. 12.11	0.014

5) Regime 5 revisited:For the fifth regime from January 27, 2014 to August 11, 2015, the in-sample data of "CNY per 10^4 USD" is a horizontal line in the log-scale in the first panel in Figure 6. Therefore, although it fluctuations up and down decorated by oscillations, there is t_c (USD per 10^4 EUR)=t_c(EUR per 10^4 CNY) as found in the fixed Regime 2, while$\overline{t_c(q)}$(USD per 10^4 EUR)≠ $\overline{t_c(q)}$(EUR per 10^4 CNY).



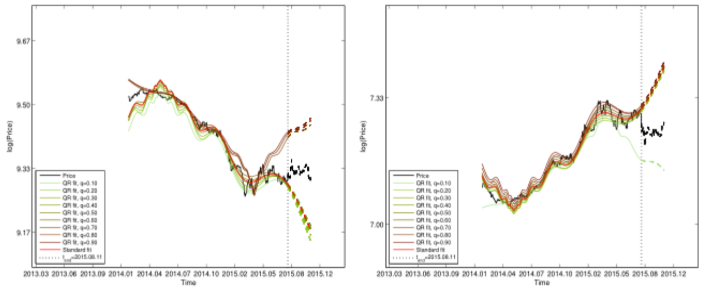


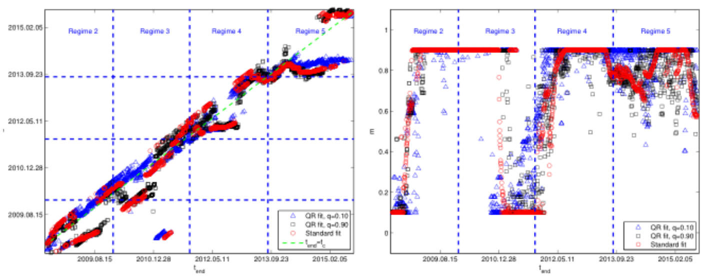
Figure 6: Red standard LPPLS fitting curve and colored quantile-based fitting curves at {q=0.10, 0.20, ..., 0.90}in Regime 5 from January 27, 2014 to August 11, 2015 of: CNY per 10^4 USD (first panel), USD per 10^4 EUR(second panel), EUR per 10^4 CNY (third panel).

Table 7: Calibrations of 4 exchange rates in Regime 5 from 2014.01.27 to 2015.08.11.

Exchange rate	m	ω	t_c	$t_c(q)$	RMSE
USD per CNY	0.900	7.932	2015.09.03	2015.07.26	0.004
CNY per USD	0.900	7.930	2015.09.03	2015.07.30	0.018
USDperEUR	0.900	8.091	2014.05.19	2014.09.06	0.004
EURperCNY	0.900	8.206	2014.05.19	2014.06.25	0.015

B. Estimates versus t_{end}

We slide the fitting windows with the length of dt=750 trading days for various individual t_{end}, and thusobtain the estimated $t_c, m, \omega$and λ by two calibration methods, which are shown as the functions of t_{end} for theperiod from Regime 2 to Regime 5 in Figure 7. Meanwhile, mean square error (MSE, i.e., L^2 norm of residual) and quantile regression error (QRE, i.e., weighted L^1 norm of residual) are respectively shown in the fifth panel and sixthpanel. From the first panel in Figure 7, we find that when the exchange rate market shifts into the Regime 5 as amarket-determined managed floating system, the estimated t_c from August 2013 to February 2015 is more stableand close to the boundary, indicating that the bubble has already ended and the calibration correctly diagnoses it.



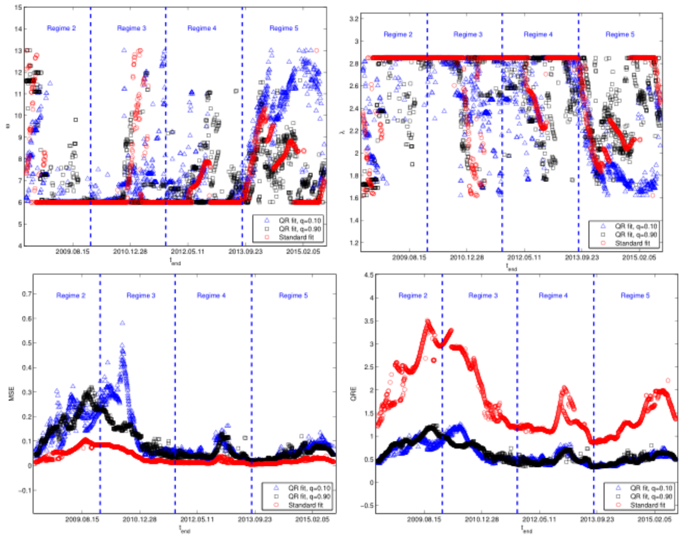


Figure 7: Evolution as a function of t_{end} of: t_c(first panel), m(second panel), ω(third panel), λ(fourth panel), mean square error (fifth panel) and quantile regression error (sixth panel) obtained from the past window withthe length of dt=750 trading days. The blue triangles show the estimates from the q=0.10 quantile regression,black squares for the q=0.90 quantile regression and red circle for the standard OLS method. The green dasheddiagonal line in first panel represents t_c=t_{end}. The dashed horizontal and vertical blue lines are the corresponding boundaries among Regime 2, Regime 3, Regime 4 and Regime 5.

C. Empirical analysis with the LPPLS Confidence indicators

As inspired from previous works on historical bubbles [14] and particularly the study on the Chinese bubble in June 2015 [11], we use the arithmetic and geometric averages over the LPPLS Confidence indicators to aggregate all these information on the time scale over which the LPPLS signal appears and on the quality of the fits. Figure 8-Figure 10 present the exchange rate time series (black curve) together with the LPPLS Confidence indicators constructed using the quantile regressions (red curves). Since the Confidence indicator can be constructed for each quantile level q, we choose to present them for q=0.10 as well as for their arithmetic and geometric averages over the 9 deciles{q=0.10, 0.20, ..., 0.90}. The geometric average is more conservative than the arithmetic average, since it requiresall deciles to give a non-zero signal in order to be non-vanishing. In contrast, the arithmetic average just needs one of the 9 deciles to give a signal.

For the time series “CNY per 10^4 USD” in the Figure 8, the LPPLS Confidence indicators are found to have strong discriminating power to identify the accelerated downward trend in the Regime 3, which are followed by arebound and a shift into Regime 4. Comparing the indicators’ performance of the “EUR against USD” in Figure9 with the “CNY against EUR” in Figure 10, it suggests: if the Confidence indicator presents the bubble signals at the top group within the Regime 2, the bottom tends to present the signals within this regime. This kind of“contagion effect” is largely due to the fixed CNY-USD” policy in Regime 2. Moreover, the signals for the

"EURagainst USD" and the "CNY against EUR" emerging in Regime 5 show a tightly coupled relationship among these currency pairs.

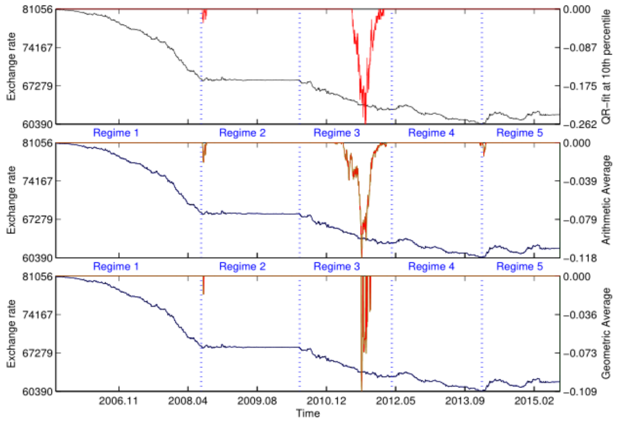


Figure 8: The LPPLS Confidence indicators of "CNY per 10^4 USD". In all three panels, the black lines are the time series while the red lines are obtained by quantile regressions. The top panel is obtained using the first decile q =0.10 quantile regression, the middle panel is the arithmetic average over the 9 deciles{q=0.10, 0.20, ..., 0.90}and the bottom panel is the geometric average over the same 9 deciles {q=0.10, 0.20, ..., 0.90}.

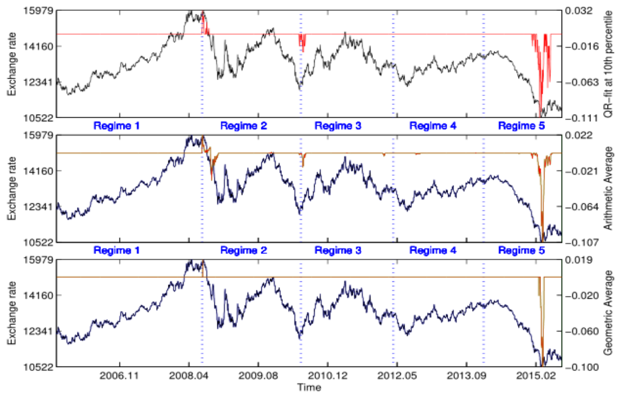


Figure 9: Same as Figure 8 but for "USD per 10^4 EUR".

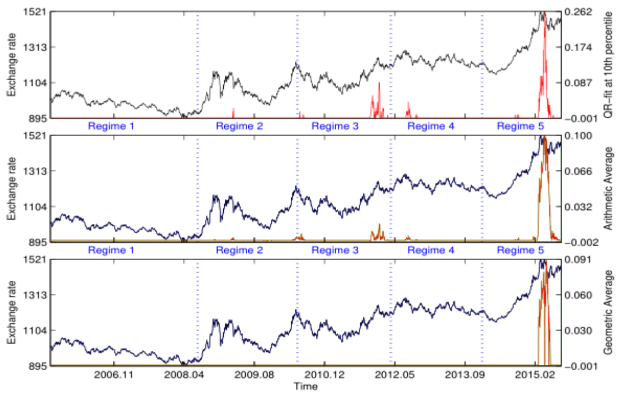


Figure 10: Same as Figure 8 but for "EUR per 10^4 CNY".

VI. CONCLUSION

This paper has implemented an alternative test for diagnosing the existence of log-periodic power law singularity structures in multi-currency pairs within China's five exchange rate regimes. The findings show that there is a super exponential growth of the "CNY against USD" in the Regime 1 from August 22, 2005 to July 7, 2008. The acceleration can be interpreted as the result of the success of the economic development of China. Due to the restrictions in trading and intervention of the China central bank, the adjustment of the exchange rate is slowed down and tends to accelerate progressively. Then it is stopped by the transition to regime 2. This kind of "transientnon-sustainable faster-than-exponential acceleration of prices" is an "apparent bubble with an under-valuation".

In other words, the price progressively accelerated to catch up and converge towards a higher fundamental value that is progressively revealed to the investors, via the progression of information discovery process, as well as social influences, herding or imitation. Besides, from the performance of LPPLS Confidence indicators integrated with the quantile regressions at 9 deciles, the signals clustered from May 2011 to March 2012 point out the terminations for this strong appreciation in the CNY against the USD. The existence of similar signals in Regime 5 adds new clues into a tightly coupled relationship among these exchange rate markets.

The International Monetary Fund's decision in 30 November, 2015 to add the Renminbi to its Special Drawing Rights currencies basket has in effect granted the Yuan the international reserve currency status. The step of SDRinclusion is a symbolic boost to its international standing, giving countries more confidence to add the RMB to their currency reserves, and giving the bank a victory and strengthen its position in domestic debates, by showing that opening up the economy brings rewards. But, it would also be a new challenge for the PBoC to keep currency stability well and guard against financial risks. We believe that a moderate market-oriented exchange rate system would be helpful for China for its economic transformation, although it might reduce the trade surplus in the short term, it would definitely lead to benefits in the long term.

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