Does China's International Competitiveness Fluctuates in Consistency with PPP Equilibrium?

Nikolaos Giannellis[1] and Georgios P. Kouretas[2]

November 29, 2011

Abstract

China's exchange rate policy is at the centre of academic and policy making interest. A widely accepted view, especially from west countries, argues that China manipulates its currency - keeping its value artificially low - so that to boost its exports. Thus, a key question is whether China's international competitiveness fluctuates in consistency with equilibrium. Following the PPP equilibrium condition and by employing linear and nonlinear unit root tests, we find mixed evidence for the exchange rates under consideration. The new evidence is that, although Chinese authorities have intervened in foreign exchange markets, China's price competitiveness was not constantly following a disequilibrium process. Our two-regime threshold model shows that small improvement (i.e. smaller than the estimated threshold) in China's international competitiveness is consistent with equilibrium, while higher improvement cannot be considered as an equilibrium phenomenon.

Keywords: China, International Competitiveness, PPP, Threshold.

JEL Classification: C22, C24, E31, F31

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[1]Department of Economics, University of Ioannina, University Campus, P.O.Box 1186, GR-45110, Ioannina, Greece.

[2]Department of Business Administration, Athens University of Economics and Business, 76 Patission Street, GR-10434, Athens, Greece.

1. Introduction

Nowadays, there is a growing interest from academics and policy makers in currency manipulation, which is usually considered as a practice of "currency war". A currency is said to be manipulated if a country intervenes systematically in the foreign exchange (forex) market to keep the value of its currency low so that to boost its exports. On the other hand, the characterization of a country as a currency manipulator is not a simple task. Not all interventions in forex markets constitute actions of currency manipulation. For example, if a currency is overvalued, the intervention in forex markets to prevent its appreciation does not violate any international agreement.[1] However, most of the countries which prevent the appreciation of their currency are already undervalued. Cline and Williamson (2010) notice that countries intervene to prevent the appreciation of their currency but they are not eager to intervene to prevent the depreciation of an undervalued currency. One possible explanation may be that these countries do not have adequate exchange rate reserves. But, this explanation does not seem to be valid if we consider that countries with adequate reserves keep preventing the appreciation of undervalued currencies.

Thus, there is no doubt that countries which prevent the appreciation of undervalued currencies have a specific and clear target. These countries hold technically the value of their currency low in order to increase their international competitiveness and increase their exports. This policy leads to large trade surpluses in these countries and to trade deficits in their trade partners.[2] This is actually why this aggressive policy triggers the academic debate and the concern of governments on currency manipulation. Deficit countries, which face large current account deficits and high unemployment rates, lay the blame on the artificially low value of other currencies. An implicit risk, as a result of the "currency war", is that deficit countries may impose restrictions on imports from currency manipulator countries.

A well-known case of country, which has been recently blamed by west countries for currency manipulation, is China. From 1994 to June 2005, the Chinese yuan was pegged to the US dollar but the gradual depreciation of the US dollar decreased

[1] Bergsten (2010) states that currency manipulation violates: (1) the international monetary rules of the International Monetary Fund (IMF) articles of agreement, and (2) the global trading rules of the World Trade Organization (WTO) charter.
[2] Subramanian (2010) states that this kind of policy is considered as highly protectionist trade policy since it is a combination of an import tariff and an export subsidy.

significantly the value of the yuan. Under the pressure of west countries, China moved from the pegged exchange rate regime to a floating one. From June 2005 to August 2008, the real effective exchange rate of the Chinese yuan appreciated by 18.6%, while it appreciated against the US dollar by 21%. After that period, the yuan was re-pegged to the US dollar until June 2010, when Chinese authorities announced that they will leave the yuan to fluctuate free in forex markets. However, the rate of the appreciation of the yuan was small and could not cover even the productivity differential between China and its trade partners.[3]

In line with the recent exchange rate developments, there is strong evidence in the literature that the yuan was undervalued (see among others, Funke and Rahn, 2005; Goldstein and Lardy, 2006; Coudert and Couharde, 2007; Guo, 2010; Benassy-Quere *et. al.*, 2011). However, there is a number of empirical works which provide somewhat different results. Cheung *et. al.* (2007, 2009) argue that the Chinese currency appears to be undervalued but the undervaluation rate is not statistically significant. Moreover, Gregory and Shelley (2011) provide evidence against equilibrium for the Chinese yuan exchange rate against the US dollar, but evidence in favor of equilibrium when the effective exchange rate of the yuan was under consideration. Similarly, Wang *et. al.* (2007) argue that the yuan real effective exchange rate was not considerably undervalued.

The present paper investigates whether the Chinese yuan exchange rate, in effective terms as well as bilaterally against major foreign currencies[4], follows an equilibrium process towards the Purchasing Power Parity (PPP) hypothesis. Furthermore, since the latter condition can be considered as a measure of an economy's price competitiveness, we seek to find whether China's price competitiveness fluctuates in consistency with PPP equilibrium. In respect with the current debate on currency manipulation, the evidence in favor of PPP hypothesis - when the yuan depreciates in real terms - implies that China's international competitiveness improvement is an equilibrium phenomenon. In contrast, if the real

[3] According to Bergsten (2010), from June to September 2010 the yuan appreciated by less than 1%.
[4] As foreign currencies we have used the US dollar, the euro and the Japanese yen. The selection of the currencies was dictated by their weight on the calculation of the Chinese yuan effective exchange rate. Once USA, Eurozone and Japan are China's major trade partners, their currencies have the highest weight on the yuan effective exchange rate. Specifically, the US dollar is weighted by 21%, while the weights on the euro and the Japanese yen are 18.4% and 16.8%, respectively.

exchange rate is not mean-reverting, thereby implying that PPP is invalid; price competitiveness adjustment is not consistent with equilibrium.

The vast majority of the empirical studies, which have examined the above task, have assumed that real exchange rates follow a linear process. However, not surprisingly, interventions in forex markets may cause nonlinearities in real exchange rate behavior. In the presence of nonlinearities, linear models are biased against the evidence of PPP equilibrium (Taylor *et. al.*, 2001). Previous studies dealing with the Chinese exchange rate have not underlined the fact that the evidence of PPP may depend on the rate of change of China's international competitiveness.[5] To fill this gap in the literature, we employ a nonlinear two-regime Threshold Autoregressive (TAR) unit root test, originally presented by Caner & Hansen (2001). A significant advantage of this test is that it allows us to discriminate between pure and partial nonstationarity. Pure nonstationarity exists when the real exchange rate is nonstationary across both regimes. Partial nonstationarity holds when the real exchange rate behaves like a unit root process in one regime and like a white noise process in the other regime. In other words, PPP may be valid in one regime, but not in the other.

To the best of our knowledge, the present paper is the first which takes account for a nonlinear two-regime process towards a threshold, which is the rate of change in China's international competitiveness.[6] This paper contributes to the literature by drawing attention to the role of China's international competiveness in accepting the PPP hypothesis. To preview our results, we have found evidence of nonlinearity in three out of the four real exchange rates under consideration. Moreover, we have found stronger evidence against PPP when China's international competitiveness (i.e. real exchange rate) increases by a rate higher than the threshold rate. Finally, small improvement in China's international competitiveness is consistent with equilibrium,

[5] To be precise, there are an adequate number of studies which have not ignored the presence of nonlinearities in the yuan real exchange rate. However, they have focused on one only source of nonlinearity, which is the transaction cost (see among others, Fan and Wei, 2006; Ahmad and Rashid, 2008). The present paper distinguishes from previous papers by shedding light on a different type of threshold variable, which is the rate of change in China's international competitiveness. Intuitively, this type of threshold is not related to transactions costs, but instead to forex intervention as a source of nonlinearity.

[6] It is important to note that this is not the first time that the test is employed in PPP literature. Although this test has not been previously employed for the real exchange rates under consideration, researchers have already applied this test to other exchange rates (see for example, Alba and Park, 2005; Ho, 2005). However, the emphasis given to international competitiveness as a threshold variable is shown for the first time here is this study.

while higher improvement cannot be considered as an equilibrium phenomenon and may be attributed to China's exchange rate policy.

The structure of the paper is organized as follows. The next section presents the econometric methodology, while section 3 presents the dataset. The empirical results are shown in section 4 and finally, a concluding section summarizes.

2. Econometric Methodology

The evidence in favor of the PPP hypothesis implies that the real exchange rate follows a mean-reverting process. In other words, the real exchange rate should follow a white-noise process. Thus, to test for the validity of the PPP hypothesis we have to test the stationary nature of the real exchange rate. As a preliminary empirical procedure, we employ the Augmented Dickey-Fuller (Dickey and Fuller, 1979, 1981); the Elliot *et. al.* (1996) GLS Augmented Dickey-Fuller; and the Phillips and Perron (1988) unit root tests, which all of them assume that the real exchange rate follows a linear process.[7]

In line with our concern on the possible nonlinear characteristics of the real exchange rate, we employ a nonlinear two-regime unit root test, originally presented by Caner & Hansen (2001), which is described below.

2.1 Two-regime TAR model

The two-regime unit root test is based on the following threshold autoregressive (TAR) model:

$$\Delta q_t = \theta_1' x_{t-1} \ell(Z_{t-1} < \lambda) + \theta_2' x_{t-1} \ell(Z_{t-1} \geq \lambda) + e_t \tag{1}$$

where, t =1,…,T, q is the real exchange rate $x_{t-1} = (q_{t-1} r_t' \Delta q_{t-1} \ldots \Delta q_{t-k})'$, $\ell(\cdot)$ is the indicator function, e_t is an independent and identically distributed error term, r_t is

[7] As these tests are very well-known and widely used tests, the reader is referred to the original papers cited above.

a vector of deterministic components (intercept and linear time trend), Z_{t-1} is the threshold variable and λ is the threshold parameter. The latter is treated us unknown and it is assumed to take values in the interval $\lambda \in \Lambda = [\lambda_1, \lambda_2]$ where $P(Z_{t-1} \leq \lambda_1) > 0$ and $P(Z_{t-1} \leq \lambda_2) < 1$.

A critical point of analysis is the endogenous selection of the threshold variable, which should be predetermined, strictly stationary, and ergodic with a continuous distribution function. Following Caner & Hansen (2001), we choose the threshold variable of the form $Z_{t-1} = q_{t-1} - q_{t-d-1}$, for the delay parameter $d \geq 1$ because it combines theoretical as well as technical advantages. Specifically, this type of the threshold variable ensures stationarity for itself under the assumption that the inflation rate differential follows a unit root or a random walk process. Moreover, the theoretical advantage stands for the ability to split our sample to two regimes according to the dynamic behavior of the real exchange rate, namely the rate of change in China's international competitiveness.

The vectors θ_1 and θ_2 are as follows

$$\theta_1 = \begin{pmatrix} \rho_1 \\ \beta_1 \\ \alpha_1 \end{pmatrix}, \qquad \theta_2 = \begin{pmatrix} \rho_2 \\ \beta_2 \\ \alpha_2 \end{pmatrix},$$

where ρ_1 and ρ_2 are the slope coefficients on q_{t-1} in the two regimes, β_1 and β_2 are the slopes on the deterministic components in the two regimes, and α_1, α_2 are the slope coefficients on $(\Delta q_{t-1}, \ldots, \Delta q_{t-k})$ in the two regimes as well. For $\lambda \in \Lambda$, the above TAR model is estimated by ordinary least squares (OLS).[8] For fixed λ, equation (1) is written as

$$\Delta q_t = \hat{\theta}_1(\lambda)' x_{t-1} \ell(Z_{t-1} < \lambda) + \hat{\theta}_2(\lambda)' x_{t-1} \ell(Z_{t-1} \geq \lambda) + \hat{e}_t(\lambda) \tag{2}$$

and the OLS estimate of the residual variance is given by $\hat{\sigma}^2(\lambda) = T^{-1} \sum_{t=1}^{T} \hat{e}_t(\lambda)^2$ .The OLS estimator of λ is this which minimizes the residual variance, i.e.

[8] Hansen (1996, 1997) has shown that, under the assumption that the error term is normally and identically distributed with zero mean and variance σ^2, OLS is equivalent to maximum likelihood estimation (MLE).

$\hat{\lambda} = \arg\min_{\lambda \in \Lambda} \hat{\sigma}^2(\lambda)$. For a given value of $\hat{\lambda}$, the estimated TAR model is as follows

$$\Delta q_t = \hat{\theta}_1' x_{t-1} \ell(Z_{t-1} < \hat{\lambda}) + \hat{\theta}_2' x_{t-1} \ell(Z_{t-1} \geq \hat{\lambda}) + \hat{e}_t \tag{3}$$

with $\hat{\theta}_1 = \hat{\theta}_1(\hat{\lambda})$, $\hat{\theta}_2 = \hat{\theta}_2(\hat{\lambda})$ and residual variance $\hat{\sigma}^2 = T^{-1} \sum_{t=1}^{T} \hat{e}_t^2$.

2.2 Testing for the Linearity Hypothesis

The linearity hypothesis (i.e. no threshold effect) is described by the following null hypothesis,

$$H_0 : \theta_1 = \theta_2 , \tag{4}$$

which is tested against the alternative that the estimated parameters in θ_1 and θ_2 are different across regimes. The null hypothesis can be tested using a standard Wald statistic,

$$W_T = T \left(\frac{\hat{\sigma}_0^2}{\hat{\sigma}^2} - 1 \right), \tag{5}$$

where $\hat{\sigma}_0^2$ is the OLS estimator of the residual variance of the linear model and $\hat{\sigma}^2$ is the OLS estimator of the residual variance of the TAR model, as it is presented in equation (2). The Wald test, as described in (5), has a nonstandard asymptotic distribution due to the presence of nuisance parameters under the null (Davies, 1977).[9] In addition, Caner and Hansen (2001) argue that the distribution may be nonstandard due to the assumption of a unit root process.[10] For this reason, Caner and Hansen (2001) introduce two bootstrap approximations to the asymptotic distribution of W_T, one based on the unrestricted estimates (unrestricted bootstrap procedure) and the other based on the restriction of a unit root (restricted bootstrap procedure).[11] The former is appropriate only when the series is stationary. If the series contains a unit root, the correct asymptotic distribution and robust p-values are achieved by the

[9] The nuisance parameter is the threshold parameter λ, which is not identified under the null hypothesis of no threshold effect.

[10] In contrast to previous TAR models that have assumed that the data are stationary, ergodic and have no unit roots, Caner and Hansen (2001) introduce the TAR model with an autoregressive unit root.

[11] For a technical and detailed description of both bootstrap methods, see Caner and Hansen (2001, p. 1563-1565).

restricted bootstrap procedure. Although, it seems that both bootstrap procedures have near identical size, Caner and Hansen (2001) suggest conducting both bootstrap procedures and selecting the larger p-value if the true order of integration of the series is unknown.

2.3 Testing for the Unit Root Hypothesis

The null hypothesis of a unit root is described by the following expression

$$H_0 : \rho_1 = \rho_2 = 0, \tag{6}$$

which means that the real exchange rate is integrated of order one, i.e. I(1). On the other hand, the series is said to be stationary autoregressive if $\rho_1 < 0, \rho_2 < 0$ and $(1+\rho_1)(1+\rho_2) < 1$. Thus, the alternative to the null hypothesis is as follows

$$H_1 : \rho_1 < 0 \qquad and \qquad \rho_2 < 0, \tag{7}$$

While the null hypothesis states that the real exchange rate has unit roots in both regimes, the alternative hypothesis states that it is stationary in both regimes. However, it is possible a series to behave like a white noise process in one regime and like a random walk process in the other regime. In other words, the real exchange rate may have a unit root in one regime and may be stationary in the other regime. This partial nonstationarity is expressed by the alternative hypothesis H_2,

$$H_2 : \begin{cases} \rho_1 < 0, & and \quad \rho_2 = 0 \\ & or \\ \rho_1 = 0, & and \quad \rho_2 < 0 \end{cases} \tag{8}$$

Because both alternative hypotheses are one-sided, the null is tested against the alternative ($\rho_1 < 0$ and $\rho_2 < 0$) using the following one-sided Wald test statistic

$$R_{1T} = t_1^2 \ell\{\hat{\rho}_1 < 0\} + t_2^2 \ell\{\hat{\rho}_2 < 0\} \tag{9}$$

where t_1 and t_2 are the t-ratios for OLS estimates $\hat{\rho}_1$ and $\hat{\rho}_2$ from TAR model (6).[12]

[12] The two-sided Wald test statistic for testing the null against the alternative ($\rho_1 \neq 0$ and $\rho_2 \neq 0$), which is given by $R_{2T} = t_1^2 + t_2^2$, is misleading and inappropriate. Moreover, Caner and Hansen (2001) have shown that the one-sided Wald test R_{1T} has more power than the two-sided Wald test R_{2T}.

Caner and Hansen (2001) suggest examining the individual t statistics (t_1 and t_2) to discriminate between the two alternative hypotheses, i.e. stationarity (H_1) and partial nonstationarity (H_2). If only one of the t-statistics is statistically significant, we should accept the alternative H_2. Finally, robust p-values are computed using a bootstrap distribution.[13]

3. Data

The exchange rates under consideration in this study are the Chinese yuan effective exchange rate, and the yuan bilateral exchange rates against the US dollar, the euro and the Japanese yen. Hence, the dataset involves monthly observations from 1993:01 to 2011:08 on nominal Chinese yuan exchange rates against the US dollar, the euro and the Japanese yen; national Consumer Price Indices (CPI) of China, USA, Eurozone and Japan; and the Chinese yuan real (CPI-based) effective exchange rate.[14] Nominal exchange rates and nationals CPI's were retrieved from the *International Financial Statistics* of the International Monetary Fund database, while the Chinese yuan real (CPI-based) effective exchange rate was taken from the Bank for International Settlements (BIS) database.

Bilateral real (CPI-based) exchange rates have been calculated based on the following formula:

$$q_t = s_t + p_t^* - p_t \, , \tag{10}$$

in which s_t is the logarithm of the nominal Chinese yuan exchange rate against the foreign currency, p_t is the logarithm of the Chinese CPI and p_t^* is the logarithm of the foreign country's CPI. Equation (10) is an identity which describes the relative version of the PPP hypothesis. Hence, the real exchange rate (q_t) measures the deviation of the nominal exchange rate from PPP equilibrium. Moreover, the structure

[13] Caner and Hansen (2001) construct two bootstrap distributions, one that imposes an identified threshold effect (identified threshold bootstrap) and another that imposes an unidentified threshold effect (unidentified threshold bootstrap). Based on a Monte Carlo analysis they suggest calculating p-values using the unidentified threshold bootstrap. For a detailed description of both bootstrap procedures, see Caner and Hansen (2001, p. 1573).

[14] The data span is subject to data availability. Namely, the estimated period runs from 1993:01 to 2011:08 for the yuan exchange rates against the US dollar and the Japanese yen, while the estimated period is restricted to 1994:01-2011:08 for the yuan effective exchange rate and to 1999:01-2011:08 for the yuan exchange rate against the euro.

of equation (10) implies that an increase in the real exchange rate stands for depreciation of the domestic currency (i.e. yuan) in real terms and increase in domestic (i.e. Chinese) competitiveness in international trade.

4. Empirical Findings

4.1 Evidence from Linear Unit Root Tests

Once the real exchange rate - as described in equation (10) - measures the deviation of the nominal exchange rate from PPP equilibrium, our concern is focused on the stationary nature of the real exchange rate. The evidence of nonstationarity implies that deviations from PPP are expected to be persistent. In contrast, if it is stationary, the real exchange rate is mean-reverting and the nominal exchange rate is expected to be driven to PPP equilibrium. With this in mind, we employ three alternative unit root tests on real exchange rates under consideration. These are (1) the Augmented Dickey-Fuller (ADF); (2) the Elliot *et. al.* (1996) GLS Augmented Dickey-Fuller (GLS-ADF); and (3) the Phillips and Perron (PP) unit root tests. All of them assume that real exchange rates follow a linear process.

The results, which are shown in Table 1, imply strong evidence against the PPP hypothesis. The three tests unanimously reveal that all bilateral real exchange rates contain a unit root, thereby implying that deviations from PPP are persistent and that China's bilateral international competitiveness does not fluctuate in consistency with equilibrium. However, the case of the real effective exchange rate is an exception. Two of the employed tests (i.e. the ADF and the DF-GLS) fail to reject the unit root hypothesis, while the PP test provides evidence of a covariance stationary real effective exchange rate at 5% level of significance. Hence, the evidence regarding the equilibrium process of the Chinese yuan in effective terms and China's overall international competitiveness is ambiguous.

4.2 Linearity Hypothesis

Although the evidence about bilateral real exchange rates was clear, we still have doubts about the validity of those results. This is because we have ad hoc assumed that real exchange rates follow a linear process. However, if real exchange rates exhibit a nonlinear behavior, standard linear unit root tests are biased against rejecting non-stationarity. Moreover, even if non-stationarity is rejected, the estimated autoregressive parameters are biased upward, thereby implying slower mean reversion than the actual one (see among others, Taylor *et. al.* 2001; Sarno *et. al.* 2004; Giannellis and Papadopoulos, 2010). Therefore, we have to test the hypothesis that real exchange rates are linear. In the lines below, we test the hypothesis that real exchange rates are not characterized by a threshold effect. If the null hypothesis is accepted, then a series is linear and the above results seem to be robust. In contrast, if the null hypothesis is rejected, then a series is characterized by a two-regime threshold process, which implies that a series may behave non-monotonically across the two regimes.

In this manner, we test the hypothesis of no threshold effect along the lines of the two-regime threshold autoregressive (TAR) model. This test is undertaken by computing a Wald test statistic (W_T) of the form of (4) and the relevant bootstrap p-values for the threshold variable (Z_{t-1}).[15] In order to identify the threshold variable, we let the delay parameter (d) be endogenously determined having in mind that the minimum delay parameter is equal to one and the maximum delay order is set equal to 12. The OLS estimate of d is the value that minimizes the residual variance. As the W_T statistic is a monotonic function of the residual variance, equivalently, the selected value of d maximizes W_T. The OLS estimates of d and λ along with the Wald test statistics and the corresponding p-values are shown in the upper part of Table 2.

The results show that linearity can be accepted in one only case. Namely, for the yuan real exchange rate against the euro, the Wald test statistic is estimated 14.7 with bootstrap p-value 0.298. There is no doubt that the series follow a linear process. Thus, we can rely on the results of standard unit root tests, which have assumed that the yuan real exchange rate against the euro exhibits linear behavior. On the other hand, there is evidence against linearity for the rest of the real exchange rates. Specifically, the yuan real exchange rate against the US dollar and the yuan real effective exchange rate are found to be nonlinear at 5% level of significance, while the yuan real exchange rate against the Japanese yen is found to be nonlinear at 10%

[15]Bootstrap p-values are calculated on the basis of both the unrestricted and restricted bootstrap procedures and by conducting 10,000 replications.

level of significance. As a consequence, a two regime threshold autoregressive model should be estimated and the corresponding threshold unit root test should be conducted for the nonlinear real exchange rates.

4.3 TAR Unit Root Test Results

The results of the two-regime threshold autoregressive unit root test are shown in Table 2, while the regime classification of the series is shown in Figures 1-3. The specification of the TAR model is shown in the upper part of Table 2, while unit root test results are shown in the bottom part of the same table.[16]

4.3.1. Against the US dollar

Starting from the yuan real exchange rate against the US dollar, it is shown in Figure 1 that, apart from the period 1997-2003, the exchange rate exhibits a general decreasing trend. The decline of the real exchange rate is equivalent to the appreciation of the yuan in real terms, and thus implies loss of international competitiveness of the Chinese economy. In line with the decreasing path of the real exchange rate, the estimated threshold parameter is found to be negative. Specifically, for d=11 and λ=-0.031, the regime classification is described as follows: The first regime occurs when the real exchange rate decreases by more than $|-0.031|$ over an eleven-month period. On the other hand, the second regime occurs when the real exchange rate decreases by less than $|-0.031|$, remains constant, or increases during the same period. In other words, China's international competitiveness decreases by more than 3.1% in regime 1, while it decreases by less than 3.1%, remains constant, or increases in regime 2.

Our main concern is whether changes in China's international competitiveness are consistent with PPP equilibrium. Thus, we proceed to the TAR unit root test by computing the test statistics R_{1T}, t_1 and t_2 given that the delay parameter equals to 11.

[16] Following Andrews (1993), we have assumed 15% minimum percentage of observations per regime.

R_{1T} tests the null hypothesis that the real exchange rate has unit roots in both regimes, against the alternative which states that it is covariance stationary in both regimes. To find whether pure or partial nonstationarity is the case, we compute t_1 and t_2 test statistics. The results, which are shown in Table 2, imply that the real exchange rate behaves like a unit root process across both regimes. Namely, despite the presence of nonlinear behaviour, there is common evidence against PPP hypothesis for both regimes. Therefore, no matter the regime, China' bilateral - against the USA - international competitiveness does not fluctuate in consistency with PPP equilibrium.

4.3.2. Against the Japanese yen

Apart from few periods, in which the yuan real exchange rate against the Japanese yen increases (i.e. 1999-2000; 2002-2003 and 2009-2011), the real exchange rate is generally decreasing. An increase in the real exchange rate implies real depreciation of the Chinese yuan and improvement in China's international competitiveness. In contrast, a decrease in the real exchange rate reveals that the yuan appreciates in real terms and thus, China's international competitiveness deteriorates. As in the case of the exchange rate against the US dollar, the delay parameter is equal to 11 and the threshold parameter is found to be negative as well. With d=11 and λ=-0.135, real exchange rate observations are divided into two regimes according to the following regime classification. In regime 1, the real exchange rate (i.e. China's price competitiveness) decreases by more than $|-0.135|$ (i.e. 13.5%) over an eleven-month period. While in regime 2, the real exchange rate (i.e. China's price competitiveness) declines by less than 13.5%, remains stable, or rises during the same period. The division of the series into two regimes is shown in Figure 2.

Test statistics, R_{1T}, t_1 and t_2, are calculated as before and the results are presented in the bottom part of Table 2. R_{1T} test statistic is 13.7, while the bootstrap p-value of accepting the null hypothesis is 0.21. This means that there are signs that the real exchange rate is non-stationary in both regimes. However, t_1 and t_2 test statistics provide quite interesting implications. Test statistic t_1 is equal to 3.70 with p-value 0.04, but test statistic t_2 equals 2.11 with p-value 0.44. These estimates reveal that the real exchange rate behaves as a stationary series in regime 1 (at 5% level of significance) and as a non-stationary series in regime 2. In terms of the PPP hypothesis, this evidence implies that PPP is established when China's international competitiveness (bilaterally against Japan) decreases by more than 13.5%. On the contrary, PPP cannot be valid when China's international competitiveness decreases by less than 13.5%, remains constant, or increases. As a consequence, only the loss of China's price competitiveness by more than this rate can be considered as an equilibrium phenomenon. If this is the case (i.e. regime 1), the estimated half-life (hl= 7.802) implies very fast reverting process towards PPP equilibrium. This means that when China's price competitiveness declines by more than 13.5%, deviations from PPP equilibrium are expected to decrease by 50% in less than 8 months.[17]

As shown in Figure 2, a large share of observations fall to regime 1 (stationary regime), while regime 2 is present during 1994; from 1999 to 2001; from 2003 to 2005 and from 2009 until the end of the estimated period. All these sub-periods coincide with periods in which China was blamed for keeping the value of its currency low. However, an interesting fact that stems from this analysis is that this exchange rate was not continuously away from PPP equilibrium. For example, in the last sub-period, observations are almost equally distributed into the two regimes. This would imply that there is no strong evidence that China follows a manipulation rule, under which the yuan is constantly kept at an artificially low level.[18]

4.3.3. Effective Exchange Rate

The yuan real effective exchange rate was in general up-warding, except three periods, such as from 1998 to 2000; from 2002 to 2005 and at the second half of 2009. The increasing trend of the real effective exchange rate implies gains for China in terms of its overall international competitiveness, while the decreasing trend implies loss in China's overall international competitiveness. According to the specification of the TAR model, which is shown in Table 2, the delay parameter is equal to 2 and the threshold parameter equals 0.02. Because of the positive value of

[17]The half life is estimated based on the following formula: $\ln(0.5)/\ln(\hat{\rho}+1)$, where $\hat{\rho}$ is the estimated autoregressive parameter of the TAR model in regime 1.

[18]This argument does not imply that Chinese monetary authorities did not intervene, in the forex market, preventing the appreciation of the yuan. What this statement argues is that there is no evidence that all interventions (if they exist) were in contradiction with PPP equilibrium. Thus, there is no strong evidence of the presence of a consistent currency manipulation policy.

the threshold parameter, real effective exchange rate regime classification differs from the two previous cases. Specifically, the real effective exchange rate increases by less than 0.02 (i.e. 2%), remains stable or decreases over a two-month period in regime 1, while it increases by more than 2% during the same period in regime 2. Equivalently, this means that regime 1 occurs when China's international competitiveness increases by less than 2%, remains stable or decreases, and regime 2 occurs when the international competitiveness of the Chinese economy rises by more than 2%.

Having estimated the parameters of the TAR model, we calculate test statistics R_{1T}, $t_{1,}$ and t_2 and the corresponding bootstrap p-values to investigate the unit root hypothesis. Recall that R_{1T} tests the null hypothesis of a unit root in both regimes against the alternative that the series is stationary across both regimes. The results, which are shown in the bottom fraction of Table 2, confirm the null hypothesis as the estimated value of the test statistic is 7.52 and the bootstrap p-value is 0.22. However, this evidence is not sufficient in determining whether pure or partial nonstationarity characterizes the real effective exchange rate. As earlier, we focus on t_1 and t_2 test statistics. The former (t_1) equals 2.72 with p-value 0.09, while the latter (t_2) is equal to 0.37 with p-value 0.71. To interpret these results, there is evidence of stationarity in regime 1 (at 10% level of significance) and non-stationarity in regime 2. Thus, there is evidence of partial nonstationarity. By combing these results with the above regime classification, this finding reveals that the increase of China's overall international competitiveness by more than 2% is not an equilibrium phenomenon and thus, PPP hypothesis does not hold. In contrast, when Chinese overall international competitiveness rises by less than 2%, remains stable, or declines, PPP can be accepted as a long-run equilibrium relationship. In other words, in regime 2, the effective exchange rate reverts to equilibrium. The speed of the reverting process is given by the estimated half-life, which is found to be equal to 13.513. This means that when china's price competitiveness increases by less than 2%, remains stable or decreases, PPP deviations are diminishing by 50% in about 13.5 months.

The division of the series into two regimes is shown in Figure 3. Although regime 1 seems to be the prevailing regime, observations that belong to regime 2 are present in the whole estimated period. In other words, observations of the first regime are followed by observations of the second regime and vice-versa. Therefore, we have not found evidence that there are entire periods in which either PPP holds or it does not hold. Consequently, there is no strong evidence that China has followed a lucid manipulation rule so that to keep technically the value of the yuan against a basket of currencies low. On the other hand, the existence of observations, which belong to regime 2, in the whole sample reveals that the effective exchange rate was not permanently consistent with PPP equilibrium. The implied misalignment may be attributed to the Chinese exchange rate policy, which in some periods prevented the loss in Chinese international competitiveness.

5. Concluding Remarks

This paper investigated whether Chinese yuan exchange rates against the US dollar, the euro, and the Japanese yen as well as the yuan effective exchange rate follow an equilibrium process towards the PPP hypothesis. Special attention has been paid to the implications underlying the PPP condition. Namely, apart from the equilibrium process of the nominal exchange rate, we examined if China's international competitiveness fluctuates in consistency with PPP equilibrium. Our study was motivated by the growing academic and policy makers' debate about the role of China's exchange rate policy, the low value of the yuan and consequently, the focus on the question of whether China acts as a currency manipulator. Our preliminary results, based on unit root tests in which the linearity hypothesis is taken for granted, confirm that PPP hypothesis cannot be accepted and equivalently, China's price competitiveness does not follow an equilibrium process. However, the presence of nonlinearities in three out of the four real exchange rates invalidates the majority of our results. The yuan real exchange rate against the euro was found to follow a linear process. Thus, given the results from standard unit root tests, there is evidence that the corresponding nominal exchange rate is not consistent with PPP equilibrium. As a consequence, China's price competitiveness improvement (against the Eurozone) is not an equilibrium phenomenon.[19]

For the rest of the real exchange rates, the results of the nonlinear TAR unit root test bring new and interesting findings to light. The yuan exchange rate per US dollar was found to be away from PPP equilibrium in the whole sample (i.e. across both

[19] However, we have to keep in mind that the small span of the data, in the case of the euro exchange rate, may have affected the power of the linearity test.

regimes). Hence, China’s price competitiveness (against the USA) does not follow an equilibrium process regardless of the regime that the real exchange rate belongs to. On the other hand, there is evidence that the yuan exchange rate per Japanese yen follows an equilibrium process in regime 1, but it is found to be away from PPP equilibrium in regime 2. When China’s price competitiveness declines by more than 13.5% (regime 1), deviations from PPP equilibrium are expected to decrease by 50% in less than 8 months. Similarly, the yuan effective exchange rate moves towards the PPP equilibrium in regime 1, whereas there is evidence against the PPP hypothesis in regime 2. The estimated regime classification implies that when china’s price competitiveness increases by less than 2%, remains stable or decreases, PPP deviations are diminishing by 50% in about 13.5 months.

The new evidence that stems from this analysis is that, apart for the exchange rates against the dollar and the euro, the rest of the exchange rates were not constantly away from PPP equilibrium. Therefore, China’s price competitiveness (bilaterally against Japan as well as the overall) was not permanently following a disequilibrium process. Our results reveal that small improvement in China’s international competitiveness is consistent with equilibrium, while higher improvement cannot be considered as an equilibrium phenomenon. In terms of the question of whether China can be characterized as a currency manipulator, we did not find entire periods in which China’s international competitiveness increases inconsistently with PPP equilibrium. Although Chinese authorities have intervened in forex markets to prevent the appreciation of the yuan, we conclude that we did not find strong evidence confirming that China has applied an explicit and continual currency manipulation rule.

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Table 1: Linear Unit Root Tests

	Yuan per US dollar (RER)	**Yuan per euro (RER)**	**Yuan per Japanese yen (RER)**	**Yuan REER**
ADF test				
Exogenous term	Constant	Constant	Constant & trend	Constant
Lags	1	1	1	13
t-statistic	-1.492	-1.604	-2.926	-2.103
p-value	0.535	0.477	0.156	0.243
DF-GLS test				
Exogenous term	Constant	Constant	Constant & trend	Constant
Lags	1	1	1	13
t-statistic	-1.452	-1.604	-2.567	0.358
PP test				
Exogenous term	Constant	Constant	Constant & trend	Constant
Bandwidth	2	3	3	6
t-statistic	-1.547	-1.386	-2.896	-3.254
p-value	0.507	0.587	0.165	0.018*

Notes: (1) The above bilateral exchange rates as well as the effective exchange rate are real exchange rates. Thus, RER refers to real exchange rate and REER stand for real effective exchange rate. (2) ADF test is the Augmented Dickey-Fuller unit root test. (3) DF-GLS test stands for the Elliot et al (1996) GLS augmented Dickey-Fuller test. (4) PP test stands for the Phillips and Perron (1988) unit root test. (5) The lag length has been automatically selected by the Schwarz criterion. (6) For the DF-GLS test, critical values are taken from Elliot, et al. (1996), table 1, p. 825. (7) * implies rejection of the null hypothesis at the 5% level of significance.

Table 2: Nonlinear TAR Unit Root Test

	Yuan per US dollar (RER)	Yuan per euro (RER)	Yuan per Japanese yen (RER)	Yuan REER
TAR Specification				
Exogenous term	constant	constant	Constant & trend	Constant
Delay parameter (d)	11	11	11	2
Threshold parameter (λ)	-0.031	-0.116	-0.135	0.02
Linearity test				
Wald test statistic	236.0*	14.7	33.1**	15.7*
Bootstrap p-value	0.00	0.298	0.05	0.02
ρ coefficient				
Regime 1	-0.006	NA	-0.085	-0.05
Regime 2	-0.008	NA	0.029	-0.001
Unit Root test				
R_{1T} test statistic	1.41	NA	13.7	7.52
Bootstrap p-value	0.82		0.21	0.22
t1 test statistic	0.54	NA	3.70*	2.72**
Bootstrap p-value	0.65		0.04	0.09
t2 test statistic	1.06	NA	2.11	0.37
Bootstrap p-value	0.56		0.44	0.71

Notes: (1) The above bilateral exchange rates as well as the effective exchange rate are real exchange rates. Thus, RER refers to real exchange rate and REER stand for real effective exchange rate. (2) Bootstrap p-value stands for the p-value based on the Bootstrap distribution. (3) ρ is the estimated autoregressive parameter of the nonlinear TAR model. (4) R_{1T} stands for the one-sided unit root test in both regimes. (5) t_1 stand for the unit root test in regime 1. (6) t_2 stands for the unit root test in regime 2. (7) * (**) implies rejection of the null hypothesis at 5% (10%) level of significance. (11) NA stands for non-applicable.

Figure 1: Regime Classification of the yuan real exchange rate per US dollar

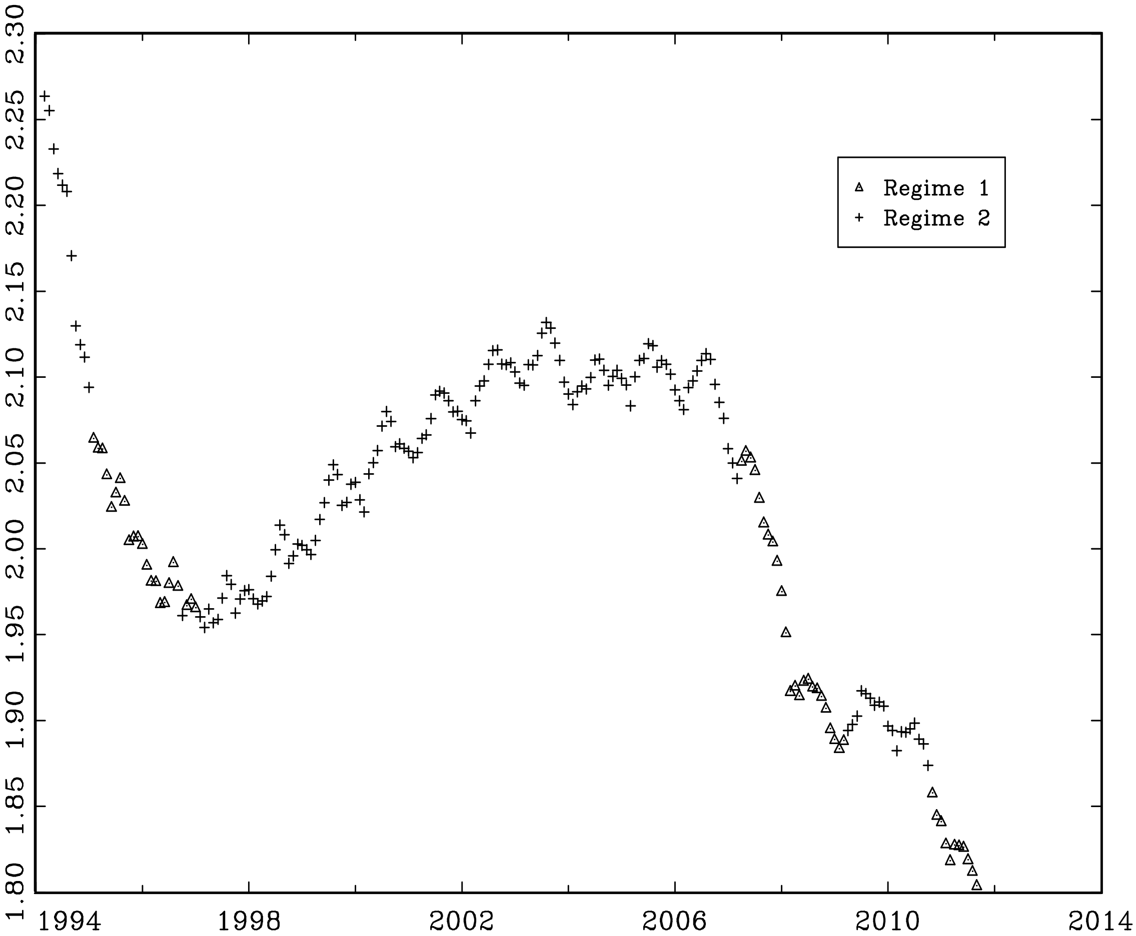

Figure 2: Regime Classification of the yuan real exchange rate per Japanese yen

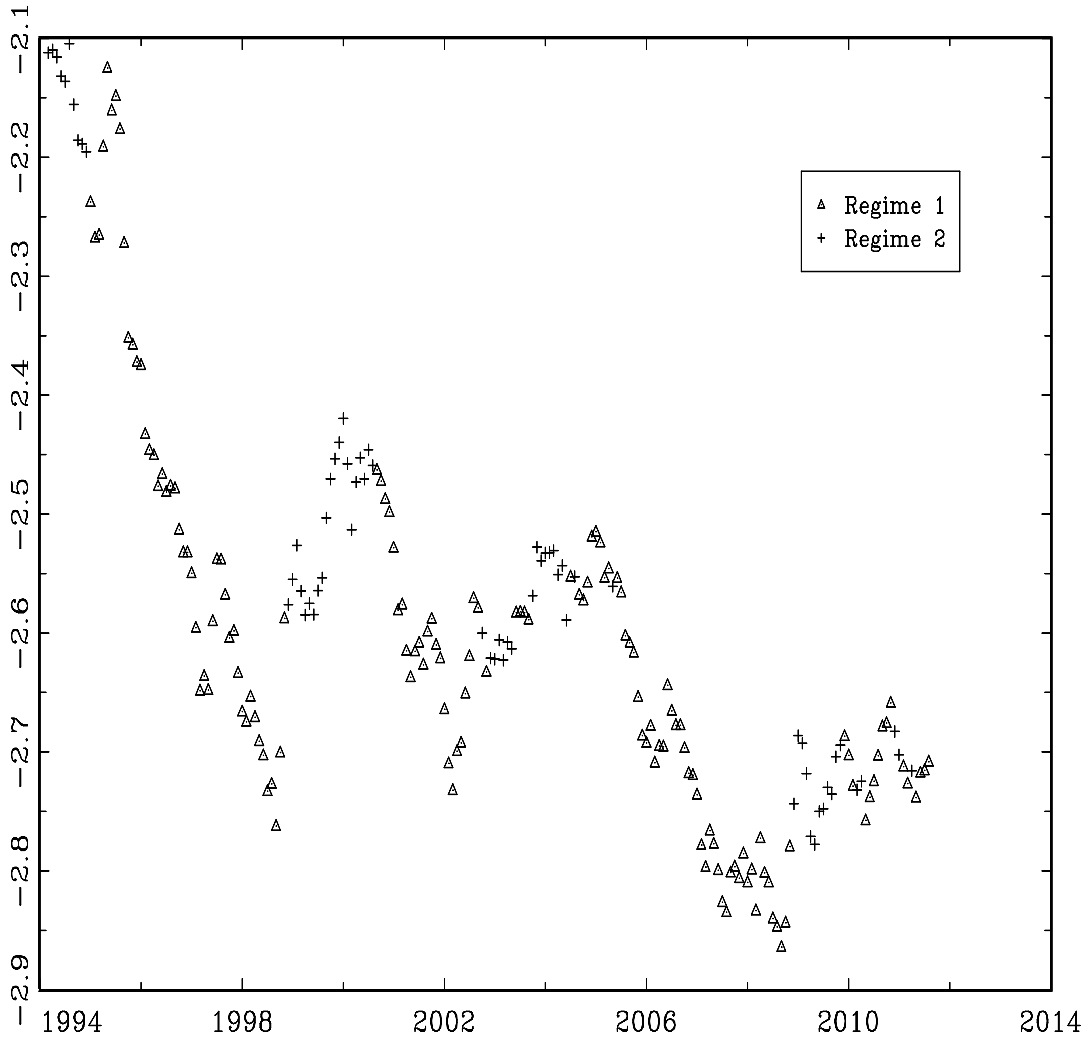

Figure 3: Regime Classification of the yuan real effective exchange rate