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

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Abstract

China's exchange rate policy is at the centre of academic and policy making interest. A widely accepted view, mainly from the U.S. and the Eurozone, argues that China manipulates its currency - keeping its value artificially low – in order to boost its exports. Thus, a key question is whether China's international competitiveness fluctuates in consistency with PPP equilibrium. Following the PPP equilibrium condition and by employing linear and nonlinear unit root tests, we find that China's price competitiveness was not constantly following a disequilibrium process. Our two-regime threshold model shows that PPP equilibrium was confirmed in periods of relatively high - compared to the estimated threshold - rate of real yuan appreciation. Moreover, we find that the fixed exchange rate regime cannot ensure external balance since it can neither establish equilibrium in the foreign exchange market, nor confirm that China's international competitiveness adjustment follows an equilibrium process. However, recent studies have shown that monetary policy control and internal balance in China are satisfied only under the fixed regime. Hence, our finding implies the existence of a complex economic policy framework for China.

Keywords: China, International Competitiveness, PPP, Threshold.

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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 market to keep the value of its currency low so that to boost its exports. However, to characterize a country as a currency manipulator is not a simple task. Not all interventions in foreign exchange markets constitute actions of currency manipulation. For example, a flexible exchange rate regime may not be consistent with monetary policy objectives. In such a case, the Central Bank has to intervene to prevent exchange rate fluctuation. Moreover, if a currency is overvalued, the intervention in foreign exchange 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), argue 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, it could be argued that countries which prevent the appreciation of undervalued currencies have a specific and clear target. According to this view, 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

[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.

trade surpluses in these countries and to trade deficits in their trade partners.[2] Obstfeld (2012) argues that such global imbalances are not innocent and may cause crises in the future. 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 a country, which has been recently blamed by the U.S. and countries of the Euro area for currency manipulation, is China. China's exchange rate policy is mainly driven by the value of the yuan (renminbi) against the US dollar, while since 1995 the employed exchange rate regimes switch between a pegged regime and an appreciating crawl one. This exchange rate policy has been strongly criticized by US politicians and economists. The main argument is that China fixes the value of the yuan to a desired level so as to increase its exports. By contrast, McKinnon (2006) and Corden (2009) argue that the aim of fixing the exchange rate was not to increase China's exports. Instead, they argue the main objective was to maintain internal stability. Furthermore, McKinnon and Schnabl (2009) and McKinnon *et al.* (2009) present evidence that China had to fix its exchange rate in order to regain its monetary policy control.

In line with the recent exchange rate developments, there is rich evidence in the literature that the yuan was undervalued (see for example, Funke and Rahn, 2005; Goldstein and Lardy, 2006; Coudert and Couharde, 2007; Guo, 2010; Benassy-Quere

[2] Subramanian (2010) notes 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.

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 that the market of the Chinese yuan exchange rate against the US dollar, was deviating from the long-run equilibrium value and thus incompatible with macroeconomic fundamentals 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 provides further investigation on the issue whether the Chinese yuan exchange rate vis-a-vis major foreign currencies[3], follows an equilibrium process towards the Purchasing Power Parity (PPP) hypothesis. Namely, independently of the economic policy objectives (i.e. current account surplus or internal stability), we investigate whether the adopted exchange rate policy can lead to the achievement of equilibrium in the foreign exchange market. 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 – can provide information that China's international competitiveness improvement is an equilibrium phenomenon. In contrast, if the real exchange rate is

[3] As foreign currencies we have used the US dollar, the euro and the Japanese yen. The selection of the currencies was based on the fact that USA, Eurozone and Japan are China's major trade partners and 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.

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 aforementioned issue, assumed that real exchange rates follow a linear process. However, not surprisingly, interventions in foreign exchange 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 dealt with the Chinese exchange rate behaviour have not underlined the fact that the evidence of PPP may depend on the rate of change of China's international competitiveness.[4] To fill this gap in the literature, we employ a nonlinear two-regime Threshold Autoregressive (TAR) unit root test, originally presented by Caner and 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 accounts for a nonlinear two-regime process towards a threshold, which is defined to be the rate of change in China's international competitiveness.[5] This paper contributes to the

[4] 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 departs from previous papers by considering 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 foreign exchange market intervention as a source of nonlinearity which we argue that applies better to China's case.

[5] 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,

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 two out of the three real exchange rates under consideration. Under the presence of nonlinear behaviour, several interesting implications stem from this analysis. First, we found that PPP equilibrium was confirmed only in periods of relatively high (compared to the estimated threshold) rate of real yuan appreciation (i.e. high competitiveness loss). In contrast, PPP equilibrium could not be established in periods of low competitiveness loss. Second, these periods were directly related to China's exchange rate policy. Specifically, low loss in China's price competitiveness was observed at the time of employing the fixed exchange rate regime, while higher loss occurred during the adoption of the appreciating crawl regime. Third, the fixed exchange rate regime can neither establish equilibrium in the foreign exchange market, nor confirm that China's international competitiveness adjustment follows an equilibrium process. Fourth, Chinese monetary authorities should take into account the above limitation in forming China's exchange rate policy. Finally, an interesting finding is that the yuan exchange rate was not continuously deviating away from PPP equilibrium. Thus, there is no strong evidence that China follows a coherent manipulation rule, under which the yuan is constantly kept at an artificially low level.

The structure of the paper is organized as follows. The next section presents an overview of China's exchange rate policy, its objectives and its impact on global imbalances. Section 3 presents the econometric methodology, while section 4 presents the dataset. The empirical results are shown in section 5 and finally, a concluding section summarizes.

2005; Ho, 2005). However, the emphasis given to international competitiveness as a threshold variable is shown for the first time here is this study.

2. China's exchange rate policy and global imbalances

A prevalent view in several countries, principally in the US, is that current account imbalances, i.e. the Chinese current account surplus and the US current account deficit, are attributed to the Chinese exchange rate policy. Regardless of the source of the imbalance, Obstfeld (2012) argues that large and persistent current account imbalances may be an indicator of a crisis in the future. He argues that current account surpluses can cause the decline of the world interest rate, which in turn may lead to higher consumption and investment in deficit countries and then to higher global imbalances. Hence, the existence of global imbalances has been set at the centre of economic policy debate. Policy makers should be aware of what provokes these imbalances and how can be eliminated. In relation with our main empirical analysis, a critical question to be answered is whether the Chinese current account surplus is attributed to the Chinese exchange rate policy.

China's exchange rate policy has been mainly focused on the value of the yuan against the US dollar. In Figure 1, we present the yuan nominal exchange rate vis-à-vis the US dollar, and it is shown that the exchange rate policy has changed several times during the period under examination and can be decomposed into five stages. At sub-period 1, which lasted until the end of 1995, China introduced multiple exchange rates and controls on exchange rate transactions which made the currency inconvertible before 1994. The exchange rate unification was accompanied with the rapid depreciation of the yuan at the end of 1993, while controls on current account transactions were abolished at the same time.

At sub-period 2, from December 1995 to July 2005, the yuan was pegged to the US dollar. This policy has been strongly criticized by a large part of economists and politicians. China has been accused for keeping its currency undervalued in order

to boost its exports and run high current account surpluses (see for example, Goldstein and Lardy, 2006). The pressure for letting the yuan to appreciate has been significantly strengthened since the high rise of the Chinese balance of payment surplus in 2004. McKinnon and Schnabl (2009) argue that the dramatic increase of China's balance of payments surplus was a result of the unexpected net saving surplus and the large inflows of foreign direct investment. The former can be seen as an increased current account surplus (Figure 2), while the latter represents higher capital account surplus (Figure 3). Similarly, Anderson (2008) argues that China's current account surplus rose as a result of the high increase of the net saving surplus and the decline in the growth of imports. Corden (2009) adds one more factor, which explains the increase of the Chinese current account surplus. This is considered to be the steady productivity improvements in export and import-competing industries, which resulted to an increase in the growth of exports and decreased the growth of imports (Figure 4).

Moreover, Corden (2009) points out that the aim of fixing the exchange rate was irrelevant to any current account objective. He states that the fixed exchange rate regime was mainly chosen to maintain internal balance. Similarly, McKinnon and Schnabl (2009) argue that the aim of fixing the exchange rate was to anchor the domestic price level and stabilize the rate of growth, while McKinnon (2006) shows that this policy helped end the "roller coaster" ride in China's inflation rate and growth.

In sub-period 3, China announced on July 21, 2005 the appreciation of the yuan against the US dollar by 2.1% and a number of exchange rate policy reforms. Among them was the abandonment of the fixed regime and a move to a predictable appreciating crawl of the yuan against the US dollar. Furthermore, the yuan were

expected to be managed with reference to a basket of currencies instead of being fixed to the US dollar (Goldstein and Lardy, 2006). During sub-period 3 (i.e. from July 2005 to August 2008), the yuan appreciated against the US dollar by 21%. However, this policy was interrupted and replaced again by a pegged regime against the US dollar until June 2010 (sub-period 4).

An interesting puzzling issue arises here. What can explain the re-establishment of the pegged regime, in sub-period 4, given that China's exports and the current account surplus were increasing? If we assume that China utilized its exchange rate as a device to boost its exports, it would have reasons to re-peg its currency if exports were cutting down during the appreciation era (sub-period 3). However, Figure 4 illustrates that the growth rate of exports increased at sub-period 3, while Figure 2 provides a similar implication for the current account surplus. A possible explanation is provided by McKinnon and Schnabl (2009) and McKinnon *et al.* (2009). According to these works, China had to reinstall the fixed exchange regime to regain its control on the conduct of the monetary policy.

Specifically, after July 2005, the continuous depreciation (appreciation) of the US dollar (yuan) prevented private capital outflows from financing China' trade surplus. Domestic investors and financial institutions preferred Chinese assets rather than US dollar denominated assets because the US dollar was expected to depreciate. The degree of inadequacy of capital outflow was even higher because of the status of China as an immature creditor country.[6] Namely, as a result of the currency mismatch that was held in China, domestic private investors and financial firms faced an enormous currency risk preventing them from buying US dollar denominated assets.

[6] A country is said to be immature creditor country if it cannot lend abroad in its own currency. These countries continually accumulate claims on foreigners in an internationally acceptable currency.

The unwillingness of the domestic private sector to invest in foreign assets (US dollar assets) led to high Balance of Payments surpluses in China. To avoid excess appreciation of the yuan, Chinese monetary authorities intervened in the forex market by selling yuan and buying US dollars. The massive purchase of US dollars increased dramatically China's official exchange reserves (Figure 5), which in turn caused an unwanted rise in domestic monetary base. Although China's Central Bank put an effort to sterilize the inflationary effects of foreign reserves accumulation, China lost the control of the monetary policy and the domestic inflation increased.[7]

Furthermore, Mckinnon *et al.* (2009) argue that China had to fix its currency to protect it from the US dollar appreciation after the US credit crisis in 2008.[8] They state that the appreciation of the US dollar moved the value of the Chinese yuan upward with it. To prevent higher appreciation of the yuan against the other currencies of the world, China abandoned the appreciating crawl of the yuan and re-fixed it to the US dollar. During syb-period 4 (i.e. fixed regime), China regained the control of the monetary policy. Finally, under economic and political pressure, China entered, in June 2010, a new period of appreciating crawl against the US dollar (stage 5).

Summing up, the overview of the Chinese exchange rate policy does not provide indications that China used the exchange rate as a device to undervalue its currency so that to boost its exports. Neither can we support the view that China's

[7] China faced limitations and difficulties in sterilizing the monetary base by selling Central Bank bonds. The bonds sell caused monetary tightening which in turn led interest rates upward. The higher domestic interest rates combined with the low US interest rates caused higher capital inflow, which caused even higher capital account surpluses. Thus, Chinese Central Bank had to accumulate even higher amount of foreign reserves.

[8] The US dollar appreciation was a result of the credit crisis of 2008 and the dollar carry trade before 2008. Due to low US interest rates, investors were borrowing in US dollars and investing in other economies with higher interest rates. However, during the financial crisis, US banks claimed the repayment of the loans in order to manage their liquidity problem. So, investors had to sell foreign currencies and buy US dollars to repay their loans.

current account surplus was an exchange rate policy objective. Instead, it can be argued that China fixed the exchange rate to regain the monetary policy control and achieve internal stability. An additional reason for keeping the exchange rate stable was the status of China as an immature creditor country. Namely, China pegged the yuan against the US dollar to protect domestic holders of US dollar assets from the currency risk. However, no matter the objective of the exchange rate policy, it is still unclear whether this policy was consistent with equilibrium in the foreign exchange market.[9] In the following section we provide further insights into this issue.

3. 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 begin by analyzing the stochastic properties of the real exchange rate. As a preliminary empirical procedure, we employ a battery of linear unit root tests, such as the Elliot *et al*. (1996) and Elliot (1999) GLS augmented Dickey-Fuller and the Ng and Perron (2001) GLS versions of the modified Phillips-Perron (1988) unit root tests. For robustness we also apply the Kwiatkowski *et al*. (1992) KPSS stationarity test.[10]

Given the likelihood for the presence of possible nonlinear characteristics of the real exchange rate, we employ a nonlinear two-regime unit root test, originally presented by Caner and Hansen (2001), which is described below.

[9] McKinnon *et al.* (2009) show that the forward exchange rate was misaligned, during the yuan appreciation crawl period, as a result of the one-way bet appreciation of the yuan and the extremely low US interest rate.

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

3.1 Two-regime TAR model

The two-regime unit root test, which tests the hypothesis that the real exchange rate at levels contains a unit root, is based on the following threshold autoregressive (TAR) model:

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

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 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 and 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 $(\Delta q_{t-1}, ..., \Delta q_{t-k})$ in the two regimes as well. For $\lambda \in \Lambda$, the above TAR model is estimated by ordinary least squares (OLS).[11] For fixed λ, equation (1) is written as

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

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

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

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

3.2 Testing for the Linearity Hypothesis

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

[11] 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).

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

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).[12] In addition, Caner and Hansen (2001) argue that the distribution may be nonstandard due to the assumption of a unit root process.[13] 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).[14] 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 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.

[12] The nuisance parameter is the threshold parameter λ, which is not identified under the null hypothesis of no threshold effect.
[13] 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.
[14] For a technical and detailed description of both bootstrap methods, see Caner and Hansen (2001, p. 1563-1565).

3.3 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,

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

Since 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).[15] 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.[16]

4. Data and preliminary empirical results

The dataset consists of monthly observations from 1993:01 to 2011:08 on nominal Chinese yuan exchange rates against the US dollar, the euro and the Japanese yen as well as national Consumer Price Indices (CPI) of China, USA, Eurozone and Japan.[17] All data were retrieved from the *International Financial Statistics* of the International Monetary Fund database.

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

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

where s_t denotes the logarithm of the nominal yuan exchange rate against the foreign currency, p_t denotes 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 absolute

[15] 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}.

[16] 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).

[17] 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 1999:01-2011:08 for the yuan exchange rate against the euro.

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 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.

4.1 Evidence from Linear Unit Root Tests

Since the real exchange rate - given 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. If we are unable to reject the hypothesis of stationary, the real exchange rate is mean-reverting and the nominal exchange rate is expected to be driven to PPP equilibrium. To this end, we employ the unit root and stationarity tests given in Section 3 on the bilateral real exchange rates of yuan under consideration.

The overall results given in Table 1 imply strong evidence against the PPP hypothesis under the assumption of linearity. These tests unanimously reveal that all real exchange rates contain a unit root, thereby implying that deviations from PPP are persistent and that China's international competitiveness does not fluctuate in consistency with PPP equilibrium.[18]

[18] The GLS-ADF and the Ng-Perron unit root test results show that the null hypothesis that the real exchange rate contains a unit root cannot be rejected. Moreover, KPSS test results illustrate that the null hypothesis that the real exchange rate is stationary cannot be accepted.

4.2. Testing the Linearity Hypothesis

Given the negative evidence in favour of stationarity of the three bilateral exchange rates under the ad hoc assumption of linearity we further investigate the stochastic properties of the three alternative exchange rates. Thus, if real exchange rates exhibit 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 test the null hypothesis of linearity against the alternative of a nonlinear feature in real exchange rates. Specifically, 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. By contrast, if the null hypothesis is rejected, then the respective bilateral real exchange rate is characterized by a two-regime threshold process, which implies that this variable may behave non-monotonically across the two regimes.

Within this framework, 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}).[19] In order to identify the threshold variable, we let the delay parameter (d) be endogenously determined given 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

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

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.

Based on the reported estimates we conclude that we were unable to reject the linearity hypothesis for the case of the yuan-euro real exchange rate but we were able to reject it for the other two real exchange rates. In particular, for the real exchange rate of the yuan against the euro, the Wald test statistic is estimated 14.7 with bootstrap p-value 0.298. Therefore we argue that this real exchange rate series follow a linear process implying that the results of the standard unit root tests are still valid for this real exchange rate. This implies that the evidence in favor or against PPP is not regime dependent. Thus, given the results from linear unit root tests, there is evidence that the corresponding nominal exchange rate is not consistent with PPP equilibrium. The evidence of linear exchange rate behavior reveals that the rejection of the PPP hypothesis might not be attributed to China's exchange rate policy.[20] However, why this exchange rate is permanently away from PPP equilibrium? One possible reason is that relative prices cannot alone determine the value of the nominal exchange rate. Indeed, by plotting the first difference of the nominal exchange rate with the first difference of relative prices (see Figure 9), we observe that the exchange rate is much more volatile, implying that relative prices may not be the exclusive determinant of the exchange rate. In line with the above, MacDonald (2000) has argued that an exchange rate may be away from its equilibrium value due to non-zero interest rate differentials.

[20] Unlike the other two real exchange rates, in which the exchange rate regime does matter, the real yuan exchange rate against euro exhibits nonstationarity across both exchange rate regimes implemented by Chinese authorities, i.e. the fixed exchange rate regime and the appreciating crawl one.

A second possible explanation is related to the difficulties in accepting the PPP hypothesis arising from the fact that Eurozone is not a single country, but instead a monetary union of 17 independent European countries. These difficulties come up from the absence of full national markets integration since price convergence among EMU members has been slow. Fan and Wei (2006) have argued, for the case of China, that although domestic authorities have removed barriers in international trade, the achievement of international market integration depends significantly on the existence of intranational market integration. Consequently, the limited market integration among EMU members may have resulted in rejection of the PPP hypothesis for the yuan exchange rate against euro.

Turning our attention to the other two real exchange rates we note that the yuan real exchange rate against the US dollar is 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% level of significance. As a consequence, we estimate a two regime threshold autoregressive model for these two nonlinear real exchange rates.

5. Estimated TAR unit root tests

The results of the two-regime threshold autoregressive unit root test are shown in Table 2, while the corresponding regime classification of the series is shown in Figures 6 and 7. The specification of the corresponding TAR model is shown in the upper part of Table 2, while unit root test results are shown in the lower part of the same table.[21]

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

5.1. Real exchange rate of yuan against the US dollar

For the case of the real exchange rate of yuan against the US dollar, it is shown in Figure 6 that apart from the period 1997-2005, 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. By contrast, the rising trend of the real exchange rate, which coincides in time with the fixed exchange rate regime of sub-period 2, implies that China gains in terms of price competitiveness. In line with the decreasing path of the real exchange rate, the estimated threshold parameter is found to be negative. Specifically, for d=10 and λ=-0.057, the regime classification is described as follows: The first regime occurs when the real exchange rate decreases by more than $\left|-0.057\right|$ over a ten-month period. By contrast, the second regime occurs when the real exchange rate decreases by less than $\left|-0.057\right|$, remains constant, or increases during the same period. In other words, China's international competitiveness decreases by more than 5.7% in Regime 1, while it decreases by less than 5.7%, remains constant, or increases in Regime 2.

A graphical illustration of the above regime classification is shown in Figure 6. Not surprisingly, the time-periods of relatively high loss of price competitiveness (Regime 1) coincide with periods in which the yuan, in nominal terms, was following an appreciating crawl against the US dollar. Instead, periods of relatively low loss or gain of price competitiveness (Regime 2) correspond chronologically to periods in which the yuan was pegged to the US dollar. Specifically, the Regime 1 captures the periods during 1995; from late 2006 to late 2008 (sub-period 3) and from late 2010 until the end of the estimated period (sub-period 5), while the Regime 2 captures the

periods from 1996 to late 2006 (sub-period 2) and from 2009 to late 2010 (sub-period 4). However, regime classification of the periods during 1994 and from mid-2005 to late 2006 does not fit with the applied exchange rate policy. Although during these periods the yuan was appreciating against the US dollar, the real exchange rate fell in Regime 2. This mismatch can be explained by the very low rate of appreciation of the yuan during both periods. Specifically, the yuan was appreciating, in nominal terms, against the US dollar by no more than 0.5% on a monthly basis. Moreover, concentrating on the sub-period from mid-2005 to late 2006, the loss in China's competitiveness resulting from the small nominal appreciation of the yuan was offset by the deflationary pressures in the Chinese economy.

We further address the question whether changes in China's international competitiveness are consistent with PPP equilibrium. Thus, we implement the TAR unit root test by computing the test statistics R_{1T}, t_1 and t_2 given that the delay parameter equals to 10. 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 the lower part of Table 2, imply that there is no common evidence against PPP hypothesis across both regimes. The null hypothesis cannot be rejected via the R_{1T} and t_2 test statistics (the p-values are 0.174 and 0.632, respectively), but it can be rejected, at 10% level of significance, when employing the t_2 test statistic (p-value = 0.07). This means that the real exchange rate behaves like a stationary process in Regime 1 and it follows a unit root process in Regime 2. Thus, under the presence of nonlinear behaviour, China's competitiveness – in bilateral trade with the US - fluctuates in consistency with PPP

equilibrium only when the yuan appreciates, in real terms, against the US dollar by more than 5.7% in a ten-month period.

By combining the unit root test results with the regime classification according to the TAR model (Figure 6) and the pathway of the nominal exchange rate as shown in Figure 1, we argue that fixing the exchange rate was not consistent with foreign exchange market equilibrium. Instead, the exchange rate was following an equilibrium process only when the yuan was appreciating against the US dollar. In this case (i.e. Regime 1), the estimated half-life (hl= 14.72) implies fast reverting process towards PPP equilibrium. This means that when China's price competitiveness declines by more than 5.7% over a ten-month period, deviations from PPP equilibrium are expected to decrease by 50% in less than 15 months.[22]

In summary, two important findings emerged with respect to the bilateral yuan-dollar real exchange rate. First, China's international competitiveness fluctuation was not permanently inconsistent with PPP equilibrium. The degree of nominal appreciation of the yuan during the appreciation crawl period, apart from two small sub-periods (i.e. 1994 and mid-2005 to late 2006), was in correspondence with relative price movements. Thus, there is no sufficient evidence to state that China has followed a constant currency manipulator rule.[23] Second, the adoption of a fixed exchange rate regime was a necessary but not a sufficient condition to establish equilibrium in the foreign exchange market. Although the aim of fixing the exchange rate was to obtain monetary policy control and internal stability, instead of increasing the current account surplus (Corden, 2009; McKinnon and Schnabl, 2009; McKinnon

[22]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.

[23]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 were in contradiction with PPP equilibrium. Thus, there is no strong evidence of the presence of a consistent currency manipulation policy.

et al., 2009), foreign exchange market equilibrium requires the appreciation of the yuan.

5.2. Real exchange rate of yuan the Japanese yen

With respect to the bilateral real exchange rate of yuan against the Japanese yen we note that apart from two periods (i.e. from mid 1998 to 2000; from 2002 to 2004 and from 2009 to 2011), the real exchange rate seems to be decreasing. An increase in the real exchange rate implies real depreciation of the yuan and improvement of China's price competitiveness in trade with Japan. 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 of yuan against the US dollar, the threshold parameter is found to be negative and the delay parameter is equal to 10. With d=10 and λ=-0.056, the 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 $|-0.056|$ (i.e. 5.6%) over a ten-month period. While in Regime 2, the real exchange rate (i.e. China's price competitiveness) declines by less than 5.6%, remains stable, or rises during the same period.

The two classification regimes of the yuan vis-à-vis yen real exchange rate are shown in Figure 7. A large number of observations fall into Regime 1, while Regime 2 is present from 1998 to 2000; from 2002 to 2004 and from 2008 to 2010. Studying further Figure 7 in relation with Figure 8, it is clearly shown that China exhibits a relatively smaller loss in terms of competitiveness in its trade with Japan (Regime 2) when the nominal exchange rate of yuan against the Japanese yen depreciates. By contrast, China's trade competitiveness exhibits greater loss (Regime 1) when the

yuan appreciates, in nominal terms, against the Japanese yen.[24] It turns out that gains in international competitiveness are driven from the nominal depreciation of the yuan.[25] However, there is one exception to this finding. In the last sub-period (i.e. 2010-2011), observations are distributed into Regime 1 despite the fact that the yuan was clearly depreciating, in nominal terms, against the Japanese yen. One possible explanation could be that the rate of depreciation of the yuan was small. But, a more plausible explanation could be that any gains in competitiveness, resulting from the yuan depreciation, were offset by the greater change in the Chinese CPI compared to the Japanese one.[26]

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 10.0, while the bootstrap p-value of accepting the null hypothesis is 0.13. 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 3.16 with p-value 0.04, but test statistic t_2 equals 0.11 with p-value 0.77. 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 5.6%. On the

[24] Figure 8 shows that the yuan exhibited nominal appreciation against the Japanese yen from late 1995 to mid 1998; from 2000 to 2002 and from 2005 to mid 2007. Moreover, the yuan depreciated, in nominal terms, from 1993 to mid 1995; from late 1998 to 2000; from 2002 to 2005 and from late 2007 to 2011.

[25] Unlike the nominal exchange rate against the US dollar, which was either fixed or decreasing, the nominal exchange rate against the Japanese yen exhibits both increasing and decreasing trends, thereby implying yuan depreciation and appreciation, respectively. Given the pressure for appreciating the yuan, what can explain the depreciation of the yuan against the Japanese yen? Given that the value of the yuan was fixed to the US dollar, the depreciation of the US dollar against the Japanese yen led to the depreciation of the yuan as well.

[26] Since October 2005, China's CPI has been permanently higher than Japan's CPI. At the end of the estimated period, the CPI differential was at the highest level as a result of the increasing trend of Chinese prices and the declining, or at least stable, trend of Japanese prices.

contrary, PPP cannot be valid when China's international competitiveness decreases by less than 5.6%, 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= 16.15) implies very fast reverting process towards PPP equilibrium. Namely, when China's competitiveness declines by more than 5.6% over a ten-month period, deviations from PPP equilibrium are expected to decrease by 50% in about 16 months.

The overall evidence from the estimated TAR unit root tests implies that the real exchange rate is stationary in Regime 1, but it is non-stationary in Regime 2. Regarding the main empirical issue of the present paper, an interesting fact that stems from this analysis is that this bilateral exchange rate was not continuously deviating from PPP equilibrium. Thus, there is an adequate number of periods in which China's price competitiveness has fluctuated in consistency with PPP equilibrium. This would imply that there is no strong evidence that China has implemented a manipulation rule, under which the yuan is constantly kept at an artificially low level.

Turning now our attention to Figure 8, we provide evidence that the stationarity of the real exchange rate of yuan-yen (Regime 1) coincides with periods of nominal appreciation of the yuan, while non-stationarity (Regime 2) matches with periods of nominal yuan depreciation. A direct implication of this finding is that the depreciation of the yuan cannot restore the equilibrium in the foreign exchange market. Instead, the nominal appreciation of the yuan can be considered as an equilibrium phenomenon.

6. Summary and concluding remarks

This paper investigated whether the Chinese yuan exchange rate against the US dollar, the euro, and the Japanese yen follows 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.

Utilizing the nonlinear characteristics of real exchange rates, this paper brings new and interesting findings to light. First, the yuan exchange rate follows an equilibrium process in Regime 1 (high competitiveness loss regime), but it is found to be away from PPP equilibrium in Regime 2 (low competitiveness loss regime). Second, the evidence in favour or against PPP hypothesis depends on the fluctuation of the nominal exchange rate. Periods of high real yuan appreciation (Regime 1) coincide with periods in which the yuan, in nominal terms, was following an appreciating crawl against the US dollar. In contrast, low real appreciation or depreciation (Regime 2) corresponds to periods in which the yuan was pegged to the US dollar. Third, the pegged regime prevents China's price competitiveness from equilibrium adjustment, while the appreciating crawl of the yuan seems to be more appropriate. Thus, China should continue appreciating the yuan to establish external equilibrium.

Moreover, an important implication is that, apart from the yuan exchange rate against euro case, the exchange rate regime does matter in accepting or not the PPP

hypothesis. This condition could not be identified in periods in which the yuan was pegged to the US dollar, but it was found to be valid when the yuan was appreciating against the US dollar.[27] This means that the pegged regime is not consistent with equilibrium in the foreign exchange market. In addition, this exchange rate regime prevents China's price competitiveness from equilibrium adjustment. As a consequence, the appreciating crawl of the yuan seems to be more appropriate. At the end of the estimated period (sub-period 5), in which the yuan follows an appreciating trend (see Figure 1), both yuan real exchange rates (i.e. against the US dollar and the Japanese yen) belong to the stationary regime (see Table 2 and Figures 6 and 7), thereby implying that PPP is valid. Thus, China should continue appreciating the yuan to establish external equilibrium.

However, any policy suggestion to Chinese monetary authorities should take into account a number of policy objectives. For example, we should be aware of China's aim to establish internal stability and maintain monetary policy control. McKinnon and Schnabl (2009) and McKinnon *et al*. (2009) have argued that by fixing the value of the yuan against the US dollar, China restored the control of the monetary policy and stabilized its domestic economy. Nonetheless, we have found in this study that the fixed exchange rate regime was not appropriate for establishing equilibrium in the forex market. By combining these findings, we may argue that the fixed exchange rate regime helps to maintain internal stability, but undermines the achievement of external balance. Therefore, our findings imply that China has to form its exchange

[27]The exchange rate policy against the US dollar was dominant for the fluctuation of the yuan exchange rate against the Japanese yen. Given that China's exchange rate policy was formed based on the value of the yuan against the US dollar, the yuan exchange rate against the Japanese yen was following the trend of the US dollar exchange rate against the Japanese yen. For example, with the yuan pegged to the US dollar, the depreciation of the US dollar against the Japanese yen implies the depreciation of the yuan against the Japanese yen as well.

rate policy within a complex economic environment constrained by internal and external objectives.

Finally, 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 fluctuates inconsistently with PPP equilibrium. Apart from the exchange rate against the euro, the rest of the exchange rates were not constantly away from PPP equilibrium[28]. Therefore, China's price competitiveness was not permanently following a disequilibrium process. Our results reveal that the magnitude of appreciation of the yuan, during the appreciating crawl period, was in correspondence with relative price movements, and consequently was not manipulated by Chinese authorities. However, it is true that China has intervened a lot of times in the foreign exchange market during the pegged regime period. Although Chinese authorities have periodically intervened in forex markets to prevent exchange rate fluctuation, we conclude that we did not find strong evidence confirming that China has applied an explicit and continual currency manipulation rule[29].

[28] This finding also implies that China's economic reforms were successful in transforming the economy from a centralized to a market economy. A number of influential papers have investigated the effectiveness of China's economic reform. Young (2000) has argued that the economic reform resulted in a fragmented Chinese domestic market. In contrast, Fan and Wei (2006) have found strong evidence of intra-national price convergence in China, which implies the presence of regional market integration. Since the absence of regional trade barriers is a prerequisite for the effective abolishment of trade barriers in international trade, our findings are in line with those of Fan and Wei (2006).

[29] In an interview on March 12, 2012 Zhou Xiaochuan, People's Bank of China Governor mentioned that market forces were playing a bigger role in determining the exchange rate, in keeping with the central bank's long-term policy objective. Furthermore, he added that as China's approaches an equilibrium exchange rate, the central bank will gradually reduce substantially its intervention in the foreign exchange market. In line with this statement, since April 16, 2012 the daily floating band of the yuan against the US dollar has been increased from 0.5% to 1% (PBC Announcement, 2012 No. 4). Coupled with this statement it was also documented that China's trade balance went to a deficit of $31.48 billion, after a surplus of $27.28 billion in January. Both these events are compatible with our main findings regarding China's exchange rate policy.

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Table 1: Linear Unit Root Tests

	Yuan per US dollar (RER)	**Yuan per euro (RER)**	**Yuan per Japanese yen (RER)**
KPSS test			
Exogenous term	Constant & trend	Constant & trend	Constant
Bandwidth	11	10	11
LM-statistic	0.311*	0.268*	1.248*
DF-GLS test			
Exogenous term	Constant	Constant	Constant & trend
Lags	1	1	1
t-statistic	-1.452	-1.604	-2.567
Ng-Perron test with constant			
Lags	1	1	1
MZ_a	-6.433	-5.149	-5.233
MZ_t	-1.471	-1.595	-1.533
Ng-Perron test with constant and trend			
Lags	1	1	1
MZ_a	-8.884	-5.698	-13.155
MZ_t	-1.965	-1.641	-2.561

Notes: (1) RER refers to real exchange rate. (2) KPSS test is the Kwiatkowski et al. (1992) unit root test. Statistics are computed based on Newey & West (1994) robust kernel estimator of the variance, while the Bartlett kernel estimator is constructed via an automatic data-dependent bandwidth selection. Asymptotic critical values are taken from Kwiatkowski et al, 1992 (table 1, p. 166). (3) DF-GLS test stands for the Elliot et al (1996) GLS augmented Dickey-Fuller test. The lag length is automatically selected by the Schwarz criterion, while critical values are taken from Elliot, et al, 1996 (table 1, p. 825). (4) MZ_a and MZ_t test statistics are the modified versions of the Phillips & Perron (1988) Z_a and Z_t test statistics. Test statistics are calculated by Generalized Least Squares (GLS) de-trended data methodology, while the lag length is selected by the Schwarz criterion. Asymptotic critical values are taken from Ng & Perron, 2001 (table 1). (5) * 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)**
TAR Specification			
Exogenous term	Constant	constant	Constant
Delay parameter (d)	10	11	10
Threshold parameter (λ)	-0.057	-0.116	-0.056
Linearity test			
Wald test statistic	212.0*	14.7	33.1**
Bootstrap p-value	0.00	0.298	0.058
ρ coefficient			
Regime 1	-0.046	NA	-0.042
Regime 2	-0.006	NA	0.017
Unit Root test			
R_{1T} test statistic	8.27	NA	10.0
Bootstrap p-value	0.17		0.13
t1 test statistic	2.76	NA	3.16*
Bootstrap p-value	0.07		0.04
t2 test statistic	0.79	NA	0.11
Bootstrap p-value	0.63		0.77

Notes: (1) RER refers to real 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: Nominal yuan exchange rate against the US dollar

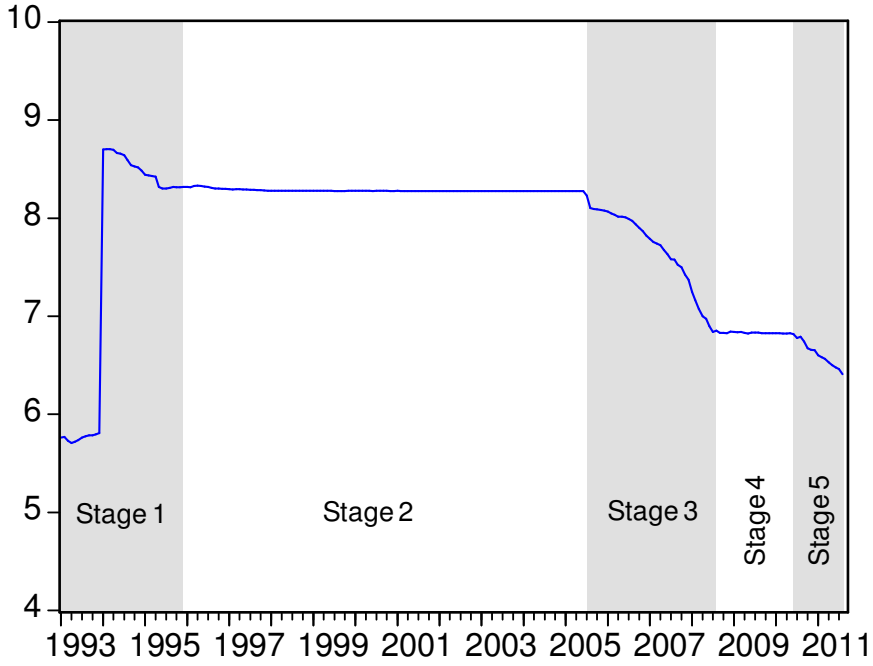


Figure 2: Chinese Current Account

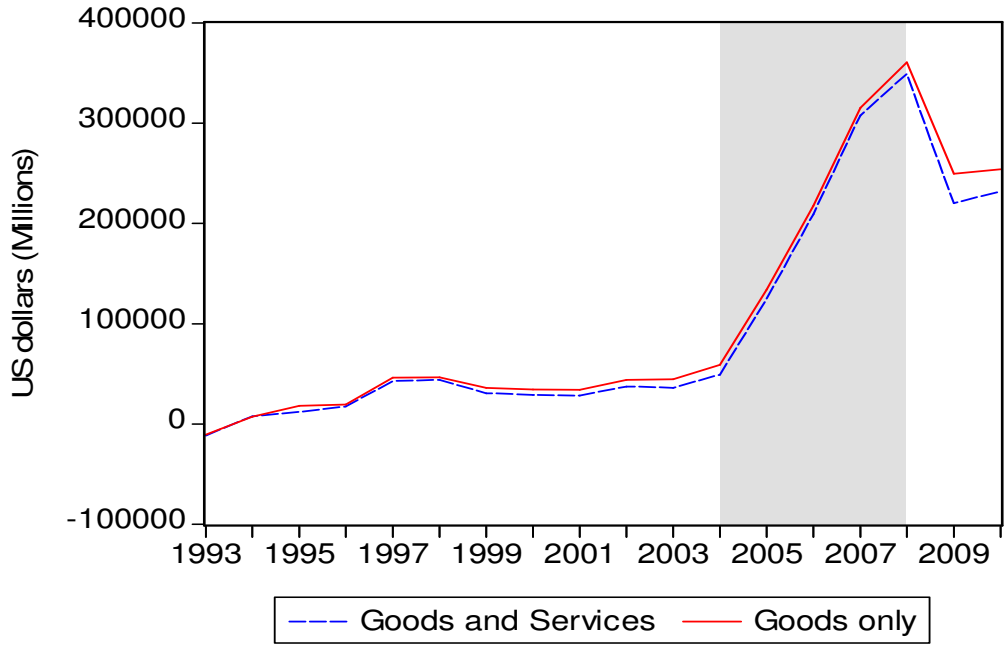
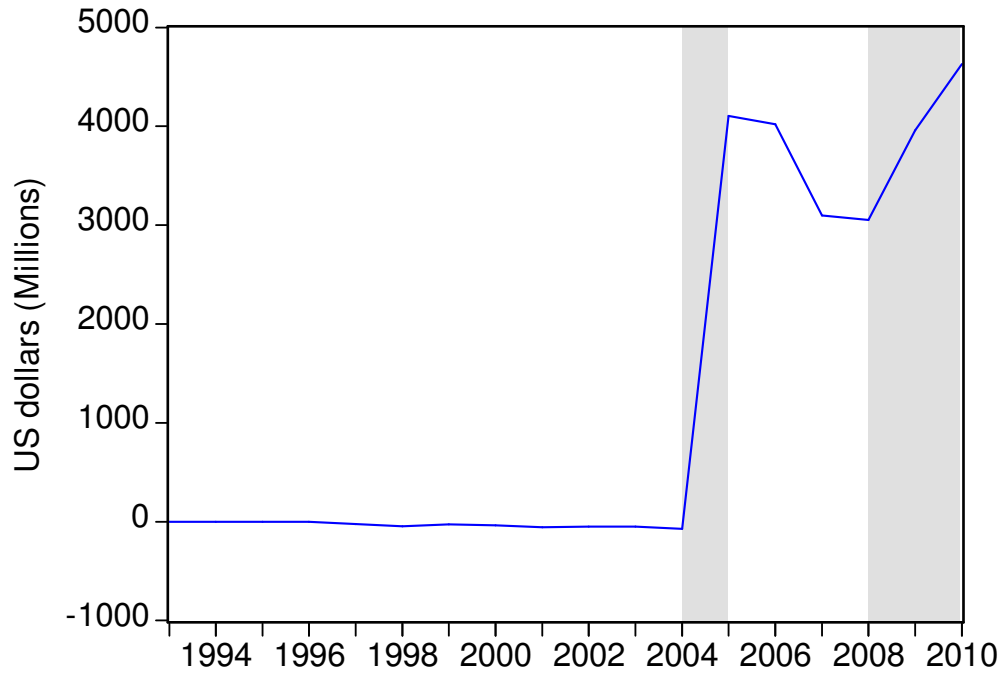


Figure 3: Chinese Capital Account



Source: International Financial Statistics (IMF)

Figure 4: China's Trade Balance

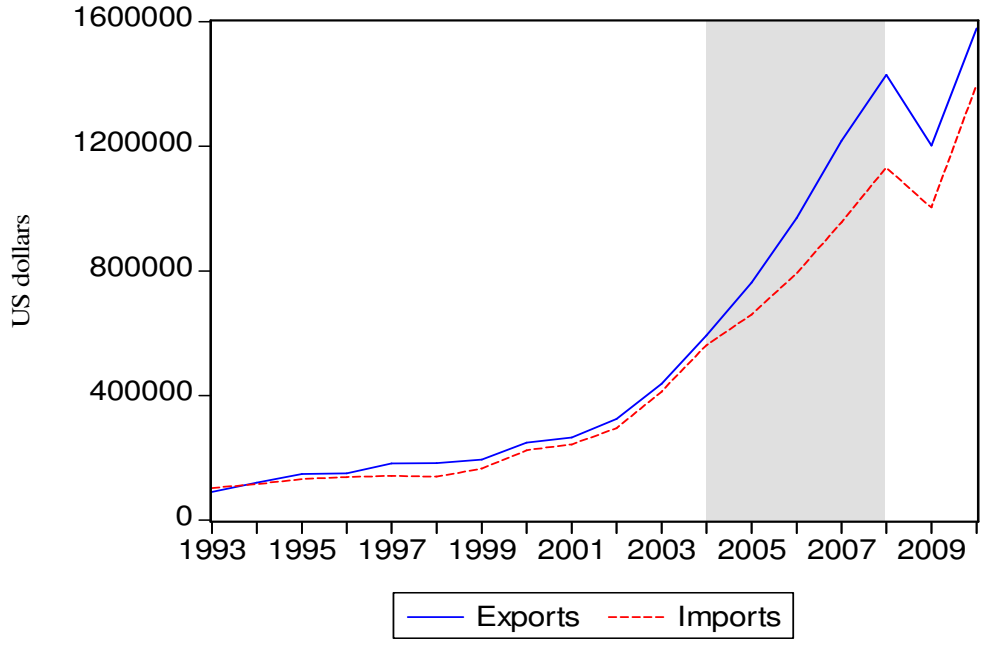


Figure 5: China's Official Foreign Exchange Reserves

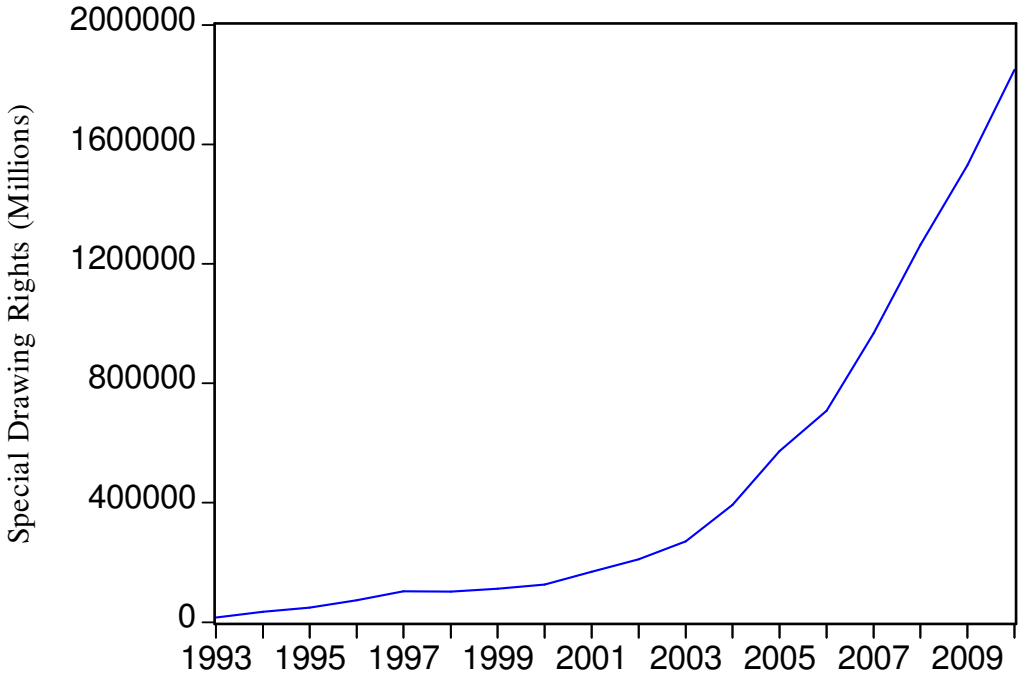


Figure 6: Regime Classification of the real yuan exchange rate against the US dollar

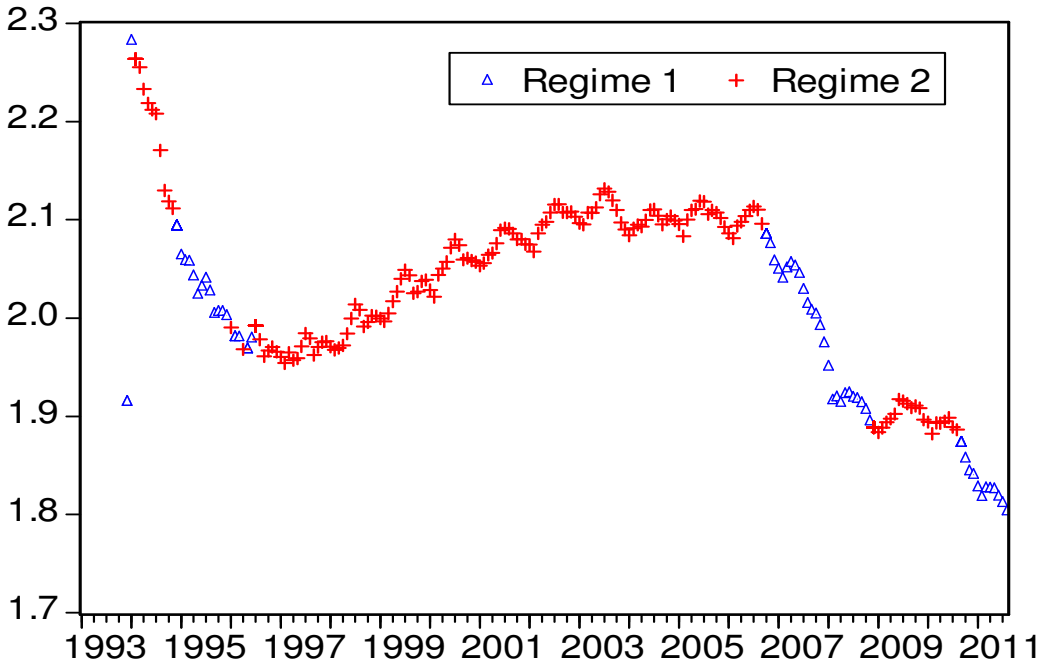


Figure 7: Regime Classification of the real yuan exchange rate against the Japanese yen

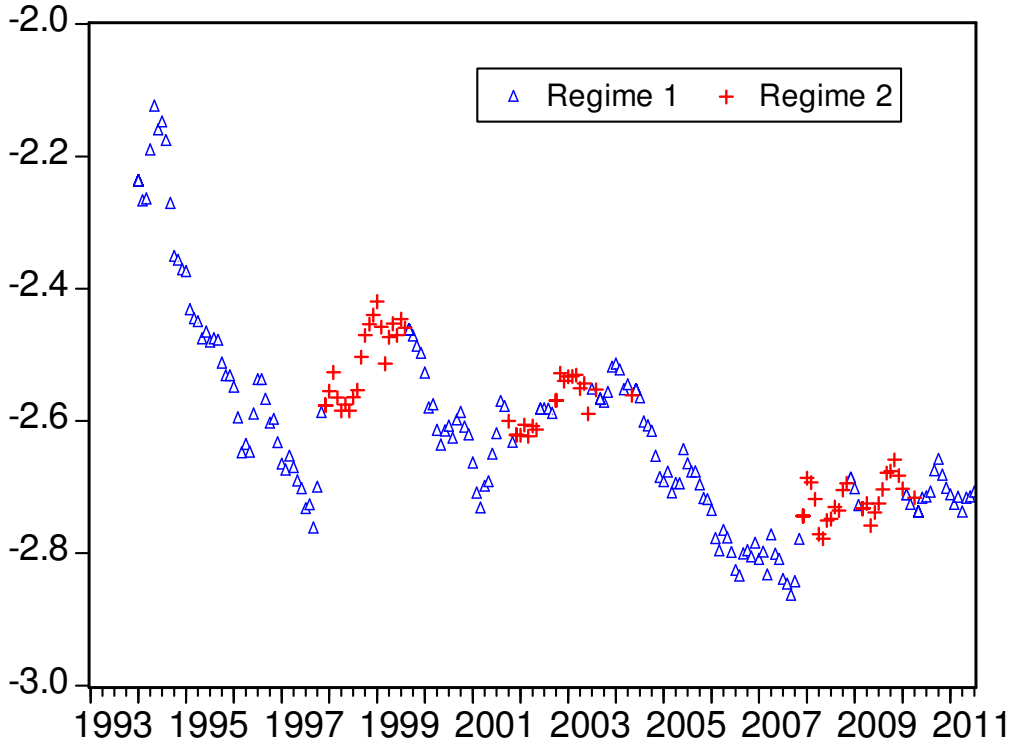


Figure 8: Nominal yuan exchange rate against the Japanese yen

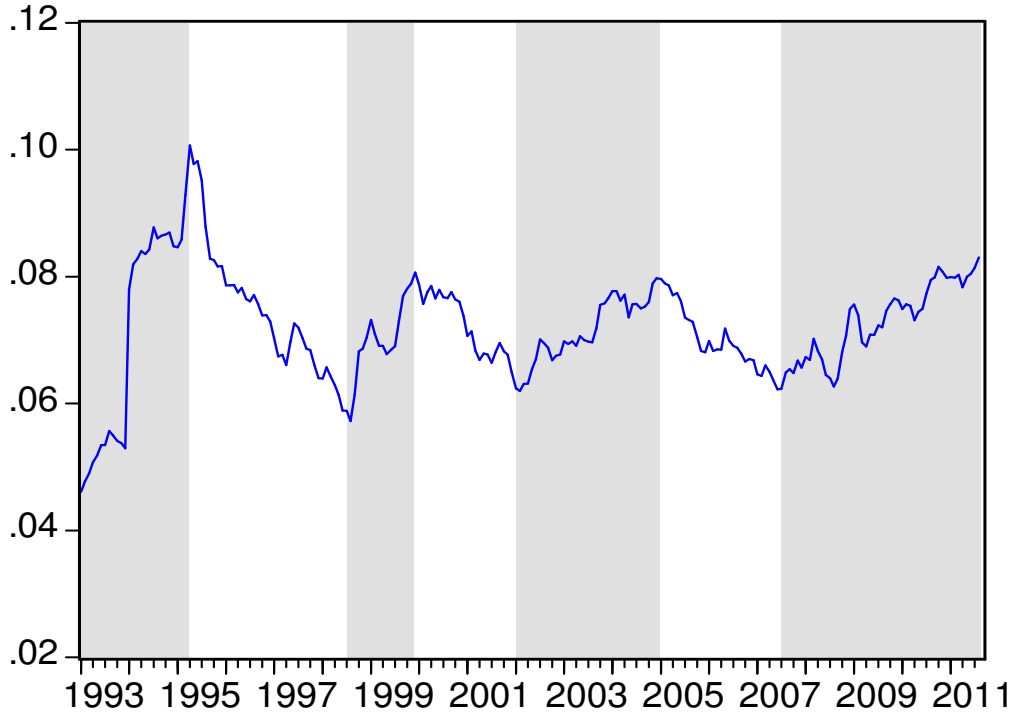


Figure 9: Nominal yuan exchange rate against euro and relative prices