Examining the Real Implications of the Purchasing Power Parity

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Abstract

This study focuses on the purchasing power between the dollar and the yuan and its usefulness in forecasting changes in exchange rates in the long run. In particular, PPP theory helps to clarify the inclination of countries with high inflation to incur a depreciation of their exchange rates. The theoretical part highlights the deviations from theory, its causes and its interconnections with other theories that analyse the relationship between exchange rates and other macroeconomic variables. Then, the validity of the theory for the USD / JPY exchange rate is examined from 1980 to 2013. The test found proof in support of the theory at 1% confidence level. Substantial emphasis is given on the effects of the asset price bubble in Japan during 1986 - 1992 and the US economic crisis of 2008 and more specifically on the behaviour of the parity during such a period of increased uncertainty.

Keywords: *PPP, exchange rates, inflation, regression, stationary, co – integration*

1. Introduction

The PPP theory can be detected to the 16th century script from the researchers of the University of Salamanca in Spain. A modern definition of PPP was given by Cassel (1918), that a given amount of a given currency should be able to buy the same quantity of goods in all countries, or it must have the same purchasing power everywhere. Over the World War I Gustav Cassel noticed that countries like Hungary, Russia, Ukraine and Germany not only had hyperinflation, but their currencies devalued versus more resistant currencies like the USD. Based on these observations he suggested the patern of PPP, which became the basis for the determination of nominal exchange rate after the World War I. Purchasing Power Parity (PPP) states that in the long run exchange rates tend to reproduce the differences in inflation rates between the two nations whose currencies are considered. The basic idea is that deviations from the theory present arbitrage possibilities, which if utilized, will bring the real exchange rates back to parity (Adler and Lehman, 1983).

The nominal exchange rates are determined in financial markets according to the logic which goes beyond the actual purchasing power of the currencies in concern (or the cost of living in their respective countries). This makes less reliable the international comparison set by converting the magnitudes of different countries in a single currency using the nominal exchange rate. In fact, the purchasing power of a given sum of money changes not only in time (due to inflation), but also in space. The problem here is that the same amount of dollars, converted in the respective local currencies at nominal rates, purchases different amount of goods in different countries, which means that the Law of One Price generally does not apply, as demonstrated by large fluctuations in real exchange rates. One way to solve this problem is to convert the monetary magnitudes to a common currency using not the nominal exchange rate quoted in the currency markets, but an exchange rate constructed in compliance with the Law of One Price (Crowder, 1996).

The present study examines a long period from 1980 to 2013, while 5 sub - samples are then constructed. More speficially, the first period is from 1980 until the beggining of the asset price bubble, (January 1980 to December 1985), the asset price bubble period constitutes the second period (January 1986 to December 1992) the third period starts after the asset bubble and finishes before the US crisis, (January 1993 to December 2006), the years of the US crisis are the next sub-samples (January 2007 to December 2009) and after the US crisis to the end of the whole sample is the fifth and last period (January 2010 to December 2013). The main objective of the present study is to test the empirical validity of PPP theory during a period of different shocks, considering that from 1980s there have been various studies on the field with diverging empirical findings.

2. Literature Review

Many studies tested the validity of PPP particularly after the fall of Breetton Woods in 1973. While PPP in the long run is so far underinquiry, it is proved that PPP in the short run fails to hold. Counting on different type of tests performed and on the size of the examined sample, recent studies found some proof in favor of PPP in the long run. Furthermore, many researchers argued that PPP fails to hold in the short run due to the limited size of samples being considered. Considering the low convergence of PPP, the econometric tests usually fail to capture the slow movements of exchange rates and consequently the shorter the period the more likely that PPP will fail to hold. An advantage in choosing data from a long period is the possible validity of the statistical tests; however during longer periods, different exchange rate regimes and critical political and economic changes possibly affect the consistency of the data set. Indeed, the period after the Bretton Woods until now provides a more uniform and, thus, appropriate sample for the examination of PPP (Lafrance and Schembri, 2002).

Recently, the number of studies covering this topic has increased dramatically. Froot and Rogoff (1995) in a review of PPP stated that what was boring only some years before, nowadays has been in the spotlight. In general, empirical studies have shown that the PPP theory is useful in predicting changes in nominal exchange rates over a relatively long period, while in the short run PPP fails to hold and the exchange rates follows a random walk. This is based on the law of one price, which states that the price of a commodity traded at international level must be the same everywhere. However, not all goods and services are traded internationally and not all goods are standardized goods (Taylor 1988; Froot and Rogoff 1995). Prior findings of Cumby and Obstfeld (1984) and Cumby and Huizinga (1988) highlighted that changes in exchange rates can be predicted since they are biased predictors of relative inflation rates. Huizinga (1987) even not very strong in statisticall terms, found proof of mean reverting. Frankel (1978) indicates that deviations from PPP are temporal and derive because of different shocks in the economy, but convergence according to PPP will occur in the long run. According to the study of Frankel for the period from 1869 to 1984 evidence in favor of PPP was found considering the exchange rate of USD/DM, while the hypothesis that the real exchange rates follow a random walk was rejected.

Balassa (1964) and Samuelson (1964) had success in treating the deviation from PPP in developing and developed countries, where they stated that the labor force in poor countries in the area of goods and services traded internationally is less productive than that of the richest countries, while differences in the sector of non-tradable products are minimal. If the price of traded goods is roughly the same in all countries, lower productivity in the traded goods and services in poor countries implies the existence of lower wages and therefore a lower level of prices of non-tradable products. Rich countries, with the highest labor productivity in the traded goods sector, tend to have prices of non-traded higher, and therefore a higher general level of prices. Very simmilar findings are offered by Bhagwati (1984), who argued that in developing countries prices are higher and this will lead to higher wages with regard to developing countries.

The study of Abuaf and Jorion (1990), where ten AR (1) regressions for dollar real exchange rates were applied found evidence in support of PPP. They tested the null hypothesis, that real exchange rates are non-stationary over the period 1973 until 1987. The results conducted to a rejection of the Null hypothesis, of joint non-stationary data. Taylor and Sarno (1998) contradicted that result since the Null hypothesis taken by Abuaf and Jorion was joint non - stationary of the real exchange rates taken into consideration, so that the null hypothesis could be rejected even if only one of the series was concluded to be stationary. According to them, this rejection of the null hypothesis cannot lead evidence in support of PPP. Isard (1995) examined the exports for highly tradable goods such as papers and clothing for countries like Germany, US and Japan, and concluding that the deviations from the law of one price are huge and to an important degree express the movements of nominal exchange rates. Philipp (2000), examined prices for the Slovenian market, revealing high differences in commodity manufactures, like bolts, nuts and screws. He found that the deviations from the law of one price are connected with the nominal exchange rate movements. Knetter (1992) ensures the most persuasive

findings where he examined the exports from a single supplier to different destinations. He found big differences in the price of German beer charged to the UK compared to the prices of German beer charged to the US.

Most of the studies of Flood and Taylor (1996), Frankel and Rose (1996), Coakley (2000), and Papell (1997), provided evidence in favor of long – run PPP, since it is taken into consideration a wide variety of countries and especially on post – Bretton Woods data. Flood and Taylor (1996) found significant evidence in favor of long – run PPP, for mean reverting, from data collected by 21 industrialized countries for the floating rate period. Beko and Borsic (2007) examined the bilateral exchange rate for Hungary, Slovenia and Czech Republic and major business partners for the period from 1992 until 2006, using ADF and KPSS, and they did not find significant evidence in favor of the PPP. Recent studies have not found a clear direction with regard to PPP hypothesis. Alba and Papell (2007), attribute the deviations from PPP to some nation specifications, such as instability of exchange rate, inflation rate, economic growth and openness relative to other countries. Empirical findings of Taylor (2001) and O'Connell (2001) revealed strong evidence that deviations from PPP are slowly mean reverting or in other words they adjust very slowly and mainly they happen because of market imperfections.

3. Methodology

In order to estimate the magnitude of certain economic effects on PPP, the initial period from 1980 to 2013 was separated into five sup-periods:

1. The period before the asset price bubble (January 1980 to December 1985)
2. The asset price bubble period (January 1986 to December 1992)
3. After the asset bubble and before the US crisis (January 1993 to December 2006)
4. The US crisis (January 2007 to December 2009)
5. After the US crisis (January 2010 to December 2013).

The model that will be considered for the examination of PPP will be as follows:

$$ls_t = \alpha + \beta_1 * lcpi\_us_t + \beta_2 * lcpi\_japan_t + u_t \quad (4)$$

Where:

ls_t - is the logarithm of the nominal exchange rate

$lcpi\_us_t$ - is the CPI of the US in logarithm

$lcpi\_japan_t$- is the CPI of Japan in logarithm

To check the stationary of the data Augmented Dickey Fuller unit root test are applied. The real exchange rate contains three variables, the nominal exchange rate and the two consumer price indexes. Each of these variables might be non-stationary and so the ADF test for the real exchange rate in levels might not be valid. Even if two variables are non-stationary the tests might not be valid in levels. In this case the valid test might be the one of the first-order differences in the real exchange rate. However, if the non-stationary variables are co-integrated then the tests of the real exchange rate in levels are accepted (Dickey and Fuller, 1979).

Hypothesis:

H0: $\beta = 0$ Null hypothesis

H1: $\beta < 0$ Alternative hypothesis

If $\beta = 0$ means that the time series have a unit root and the data are non-stationary. The authors also suggested an alternative equation with a constant included in order to check for the presence of a unit root.The amount of lagged values to be covered must be enough in order for the error term to be serially uncorrelated. This number of lagged values is selected automatically by Eviews7 based on Hannan - Quinn, Schwarz, Akaike or other criteria. If the coefficient of lagged variables indicates a value equal to zero, then the data are stationary and if the value is equal to one the time series data are non - stationary.

Linear Regression

Linear regression is an approach for assessing the relation between a dependent variable and one or more independent variable. The coefficients represent the type of relation as well as the strength the independent variables has to the dependent one. They show how much the dependent variable is expected to increase / decrease when the independent variable increases / decreases by one, keeping all the others constant. The signs tell the direction of the effect, an increase if is positive and a decrease if is negative. Using regression to monthly exchange rates and CPIs via OLS, the following model is estimated:

$$ls_t = \alpha + \beta_1 * lcpi\_us_t + \beta_2 * lcpi\_japan_t + u_t$$

The null hypothesis is that the coefficient is equal to zero, if so, not supporting our estimation model. If the p-value

is very small (less than 0.05), smaller is the possibility of the coefficient to be zero, in other words the null will be rejected. In addition, a dependent variable related with a coefficient, statistically significant, has a high importance in the estimation model. Furthermore, the objective of F test is to test the significance of the model. The F-tests indicates whether the CPI of the US and Japan influence the exchange rate or not. Finally, the t-test will conclude for the statistical significance of each dependent variable. In a perfect model the p – value would be very low with a high corresponding F-value and a high t-value.

4. Data Analysis

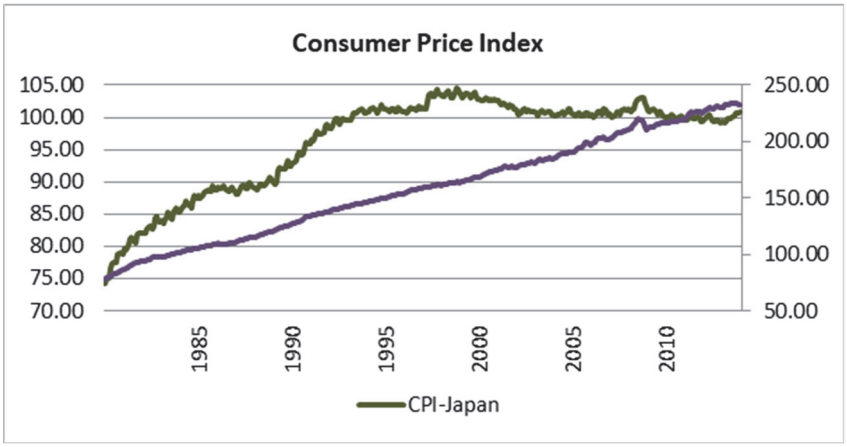
The data cover monthly observations of the exchange rates of the USD to JPY (USD/JPY) and the CPI – Consumer Price Index for the two countries. The total sample covers the period from January 1980 to December 2013, amounting to 408 observations in total. Shocks during crisis cause deviations from PPP. If in the long run PPP holds, then these deviations should be temporary. Because of arbitrage possibilities the price levels and exchange rates must realign, either the ratio of domestic price to foreign price levels will decrease or the exchange rate will devalue. As it is noticed the mean has an increasing value, or in general, the yen has appreciated in years. The raise of yen after 1985s probably can be assigned to the Plaza Accord, in which was stated that the yen was undervalued against the USD. Due to this arrangement and moving demand and supply forces in the markets, yen raised its value. During the financial crisis of 2008 the appreciation of JPY against the USD continued. This phenomenon, can be attributed to the harmed trust of the financial markets in the stability of the US economy. Also in this period, the inflation in the US was higher than the inflation in Japan, suggesting that exports of the US to Japan probably declined, causing a depreciation of the currency.

Table 1: Descriptive Statistics of Real Exchange Rate

Real Exchange Rate - Descriptive Statistics								
Period	**Mean**	**Median**	**Std Dev**	**Kurtosis**	**Skeweness**	**Max**	**Min**	**Obs**
1980 - 2013	0.014	0.014	0.007	2.706	0.508	0.030	0.004	408
1980 - 1985	0.005	0.005	0.002	5.288	0.634	0.006	0.004	72
1986 - 1992	0.010	0.010	0.001	2.875	-0.711	0.012	0.006	84
1993 - 2007	0.015	0.015	0.002	2.105	0.050	0.019	0.011	180
2008 - 2009	0.022	0.022	0.001	1.794	-0.004	0.024	0.019	24
2010 - 2013	0.026	0.027	0.002	1.509	-0.104	0.030	0.022	48

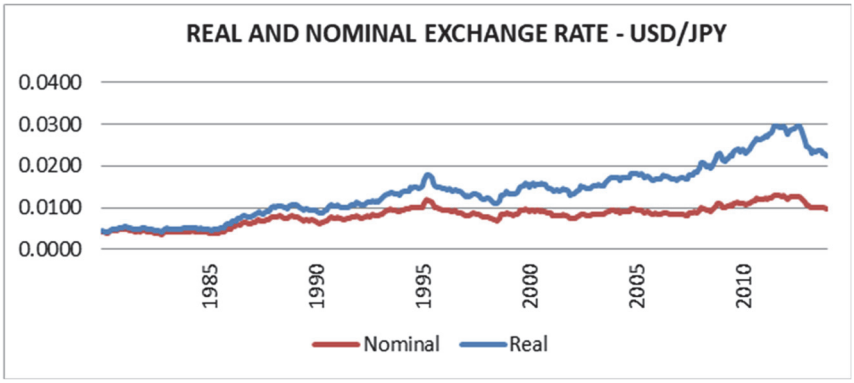
It is apparent from the above table that the median stands closer to the minimum value than the mean, suggesting the existance of enough high upper values. Also, the USD/JPY exchange rate shows a much lower standard deviation during the asset price bubble in Japan (1986 - 1992) and the financial crisis (2008 - 2009). It is noticeable that the skewness for the real exchange rate is negative during the periods of crisis, suggesting the higher probability of negative outcomes for the investors. In contrast, positive skewness that exist during 1980 - 1985 and 1993 - 2007 implies less possibility for negative returns. It is remarkably as well that the kurtosis is positive during the whole period (1980 – 2013) indicating a peaked distribution and less chances for extreme values.

Graph 1 plots the data of Japan and the US - CPI over the period 1980 - 2013. The graph of CPI shows that the series for the US have an increasing trend while for Japan there is an increasing pace from 1980 until 1998 and a stable movement thereafter.



Graph 1: Consumer Price Index for the Us and Japan

Graph 2, shows the nominal and the real exchange rates for the USD/JPY. As it can be observed by the graph, real and nominal exchange rates show a relative increased volatility. In fact, the exchange rates tend to stabilize around a lower mean, during the crises, with a lower value of standard deviation. The graph shows that there is an increasing trend for the USD/JPY exchange rates although during the last period there is a revearsing trend.



Graph 2: Real and Nominal Exchange Rate – USD / JPY

From 1995 to 1998, the volcano hit Japan more than 200 causing large losses in humans and material damages. Natural disaster is likely to cause a depreciation of the currency, as happened with the JPY, because of financial difficulties that they leave behind. From 2008 to 2011, the US dollar depreciated against the JPY due to the effects of the financial crisis that began with the collapse of some of the most well - known investment banks, like Lehman Brothers. After 2012 the US dollar began a slightly appreciation with respect to JPY, suggesting that the financial difficulties were left behind and the American economy, was starting to recover. One thing that might seem counterintuitive is the appreciation of JPY after the 2011 tsunami in Japan. Apart from the human tragedy, this natural disaster had its impact on the Japan economic performance. Yet, Yen has appreciated in value. One possible explanation for this phenomenon is that the Japanese have a lot of foreign securities, such as Asian bonds, American or European assets. So, the crisis that hit Japan caused many investors to sell a part or all of their non - yen denominated assets and bring their money back to Japan. Consequently, this caused an increase of the demand for Yen and boosted its value.

5. Analysis of Results

In the following paragraphs we present the results of the econometric analysis performed using EViews7 software. The model is with intercept and trend, and the ADF statistics are comparatively depicted at 1%, 5% and 10% levels of significance. The results of the stationary tests are in the appendix.

Linear Regression

1. 1980 - 2013

The R2 indicates the fraction of the total variance that is due to the linear relationship between the dependent and independent variables. Namely it shows how the model of linear regression is supporting the phenomenon under study. The regression seems to be strong with an R2 approximately 0.795, meaning that 79.5% of the variation of exchange rates is explained by the independent variables. The intercept, is with minus, $\alpha = -14.487$, predicting a decrease in the exchange rate by 14.487 unit if $Xi = 0$. The estimated coefficient,β_1, is aproximately 0.629, meaning that a percentage increase in the CPI of the US would result in an increase by 0.629% in the exchange rate, keeping all the variables constant. The estimated coefficient, β_2,is equal to 1.416, meaning that a percentage increase in the CPI of Japan would result in an increase by 1.416% in the exchange rate, keeping all the variables constant. Both this variables have a positive impact on the exchange rate.

Table 2: Regression output for the period 1980 – 2013

ffVariable	*Coefficient*	*Std. Error*	*t - statistic*	*Prob.*
c	-14.487	0.625	-23.179	0.000
Log(cpius)	0.629	0.048	12.908	0.000
Log(cpijapan)	1.416	0.180	7.849	0.000
Observations	408			
R-squared	0.795			
Adjusted R – squared	0.795			
F – statistic	789			
Prob (F-statistic)	0.000			

2. 1980 - 1985

The constant, is with minus, $\alpha = -11.179$, indicating a decrease in the exchange rate by 11.179 unit if the other variables are equal to zero. The estimated coefficient,β_1, is aproximately -1.906, telling that an increase in the CPI of the US would result in a decrease in the exchange rate, keeping all the variables constant. The CPI of Japan has a positive impact on the exchange rates since the estimated coefficient has a positive sign and is equal to 3.262. The regression seems to be weak with an R2 aproximately 0.178, meaning that only 17.8% of the variation of exchange rates is explained by the independent variables. The p-value is less then 0.05 pointing that the result is significant,or, there is a significant effect of the two CPIs on the exchange rates.

Table 3: Regression output for the period 1980 – 1985

ffVariable	*Coefficient*	*Std. Error*	*t - statistic*	*Prob.*
c	-11.179	2.832	-3.946	0.000
Log(cpius)	-1.906	0.687	-2.771	0.007
Log(cpijapan)	3.262	1.340	2.434	0.017
Observations	72			
R-squared	0.178			
Adjusted R – squared	0.155			
F – statistic	7.499			
Prob (F-statistic)	0.001			

3. 1986 - 1992

The constant ha a negative impact on the exchange rate, since it has a negative sign, with a value equal to -0.531.

The estimated coefficient of the first independent variable has a direct impact on the independent one, keeping all the others constant. Diversely,β_2, has an inverse relation with the exchange, causing a decrease on it, keeping all the other constant. The regression quite strong with an R2 aproximately 0.513. Approximately 51% of the variation of exchange rates is explained by the independent variables.

Table 4: Regression output for the period 1986 – 1992

ffVariable	*Coefficient*	*Std. Error*	*t - statistic*	*Prob.*
c	-0.531	1.679	-0.316	0.752
Log(cpius)	2.376	0.352	6.748	0.000
Log(cpijapan)	-3.501	0.719	-4.868	0.000
Observations	84			
R-squared	0.513			
Adjusted R – squared	0.501			
F – statistic	42.736			
Prob (F-statistic)	0.000			

4. 1993 - 2007

The constant, is with positive, $\alpha = 10.508$, indicating an increase in the exchange rate if the other variables are equal to zero. The two other coefficients,$\beta_1 \& \beta 2$, has an inverse relation with the exchange rate, meaning that an increase of these two coefficients would resul in a decrease of the exchange rate. The regression seems to be weak with an R2 aproximately 0.219, meaning that only 21.9% of the variation of exchange rates is explained by the independent variables. The p-value is less then 0.05 pointing that there is an effect of the two CPIs on the exchange rates.

Table 5: Regression output for the period 1993 – 2007

ffVariable	*Coefficient*	*Std. Error*	*t - statistic*	*Prob.*
c	10.508	2.647	3.969	0.000
Log(cpius)	-0.345	0.057	-5.991	0.000
Log(cpijapan)	-2.913	0.551	-5.285	0.000
Observations	180			
R-squared	0.219			
Adjusted R – squared	0.210			
F – statistic	24.861			
Prob (F-statistic)	0.000			

5. 2008 - 2009

The constant, is positive, α=15.147, indicating an increase in the exchange rate if the other variables are equal to zero. The two other coefficients,β_1& β2 , has a negative impact on the exchange rate, since an increase of these two coefficients would resul in a decrease of the exchange rate, because of the signs of these two coefficients. The regression is not very strong, because only 32.9% of the variation of exchange rates is explained by the independent variables.

Table 6: Regression output for the period 2008 – 2009

ffVariable	*Coefficient*	*Std. Error*	*t - statistic*	*Prob.*
c	15.147	6.473	2.339	0.029
Log(cpius)	-0.323	1.037	-0.311	0.758
Log(cpijapan)	-3.894	1.431	-2.721	0.012
Observations	24			
R-squared	0.329			

ffVariable	*Coefficient*	*Std. Error*	*t - statistic*	*Prob.*
Adjusted R – squared	0.265			
F – statistic	5.153			
Prob (F-statistic)	0.015			

6. 2010 - 2013

The intercept, is positive, $\alpha = 43.923$, indicating an increase in the exchange rate if the other variables are equal to zero. The two other coefficients,$\beta_1 \& \beta 2$, has an inverse relation with the exchange rate, meaning that an increase of these two coefficients would resul in a decrease of the exchange rate. The regression seems to be weak with an R2 aproximately 0.260, meaning that only 26% of the variation of exchange rates is explained by the independent variables. The p-value is less then 0.05 pointing that there is an effect of the two CPIs on the exchange rates.

Table 7: Regression output for the period 2010 - 2013

ffVariable	*Coefficient*	*Std. Error*	*t - statistic*	*Prob.*
c	43.923	13.414	3.274	0.002
Log(cpius)	-1.088	0.465	-2.340	0.023
Log(cpijapan)	-9.226	2.862	-3.222	0.002
Observations	48			
R-squared	0.260			
Adjusted R – squared	0.228			
F – statistic	7.945			
Prob (F-statistic)	0.001			

6. Conclusions

PPP has been an attraction for a large number of researchers. So far, even in its long run form, PPP has faced difficulties to determine empirically. The findings possibly highlight difficulties in measuring the composition of a similar basket of goods in different countries and the impact of additional parameters, such as transaction costs, the being of non-tradable goods or productivity shocks, affecting the balance of exchange rate. The deviation from the theory of PPP may arise either due to the basket of goods included by Consumer Price Index in the respective countries or in the variation of weights set to goods. Also, shocks in the economy arising form unexpected events may affect real exchange rate. Despite the fact that no model has been suitable in predicting the conduct of exchange rates in the short – run, there are some notions that have a significant role in defining the conduct of exchange rates in the long – run, mentioning here the efficient market hypothesis, thus, only unanticipated events may generate variations in the exchange rates. PPP specifies the long run conduct of exchange rates. Factors at the back of PPP will equalize the buying power of currencies, even it will take years for this realignment.

The main objective of the paper was to define the validity of the theory of Purchasing Power Parity for USD and JPY exchange rates from 1980 to 2013. Augmented Dickey Fuller has been used to check the stationarity of the time series. After that, the regression was applied in order to calculate the coefficients, in order to see their signs and statistical significance. The test found proof in support of the theory at 1% confidence level.

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Appendix: Stationary tests

Real Exchange Rate							
Level					**First difference**		
Period	**Obs**	**t-statistic**	**Critical value**	**H0**	**t-statistic**	**Critical value**	**Null hypothesis**
1980-2013	406	-2.417	-3.981*	Fail to reject	-15.066	-3.981*	Reject
			-3.421**	Fail to reject		-3.421**	Reject
			-3.133 ***	Fail to reject		-3.133 ***	Reject
1980-1985	70	-2.417	-4.094*	Fail to reject	-5.976	-4.094*	Reject
			-3,475**	Fail to reject		-3,475**	Reject
			-3,165***	Fail to reject		-3,165***	Reject
1986-1992	82	-2.682	-4,074 *	Fail to reject	-6.734	-4,074 *	Reject
			-3,465**	Fail to reject		-3,465**	Reject
			-3,159***	Fail to reject		-3,159***	Reject

Real Exchange Rate								
Level					First difference			
Period	Obs	t-statistic	Critical value	H0	t-statistic		Critical value	Null hypothesis
1993-2007	178	-2.366	-4,010 *	Fail to reject	-10.322		-4,010 *	Reject
			-3,435**	Fail to reject			-3,435**	Reject
			-3,142***	Fail to reject			-3,142***	Reject
2008-2009	21	-4.368	-4,467 *	Fail to reject	-3.851		-4,467 *	Fail to reject
			-3,644**	Reject			-3,644**	Reject
			-3,261***	Reject			-3,261***	Reject
2010-2013	47	-0.7145	-4,165 *	Fail to reject	-5.261		-4,171 *	Reject
			-3,508**	Fail to reject			-3,511**	Reject
			-3,184***	Fail to reject			-3,185***	Reject

Nominal Exchange Rate								
Level					First difference			
Period	Obs	t-statistic	Critical value	Null hypothesis	Obs	t-statistic	Critical value	Null hypothesis
1980-2013	406	-2.427	-2.281*	Reject	406	-14.797	-3.981*	Reject
			-3.421**	Fail to reject			-3.421**	Reject
			-3.133 ***	Fail to reject			-3.133 ***	Reject
1980-1985	70	-2.312	-4.094*	Fail to reject	70	-6.006	-4.094*	Reject
			-3,475**	Fail to reject			-3,475**	Reject
			-3,165***	Fail to reject			-3,165***	Reject
1986-1992	82	-2.765	-4,074 *	Fail to reject	82	-6.857	-4,074 *	Reject
			-3,465**	Fail to reject			-3,465**	Reject
			-3,159***	Fail to reject			-3,159***	Reject
1993-2007	178	-2.833	-4,010 *	Fail to reject	189	-9.896	-4,010 *	Reject
			-3,435**	Fail to reject			-3,435**	Reject
			-3,142***	Fail to reject			-3,142***	Reject
2008-2009	21	-3.741	-4,467 *	Fail to reject	21	-4.451	-4,441 *	Reject
			-3,644**	Reject			-3,633**	Reject
			-3,261***	Reject			-3,254***	Reject
2010-2013	47	-0.949	-4,165 *	Fail to reject	47	-5.261	-4,171 *	Reject
			-3,508**	Fail to reject			-3,511**	Reject
			-3,184***	Fail to reject			-3,185***	Reject

*Critical values marked with * are at 1% confidence level/marked with **at 5 % confidence level/marked with *** at 10% confidence level*

CPI – US								
Level						First difference		
Period	Obs	t-statistic	Critical value	Null hypothesis	Obs	t-statistic	Critical value	Null hypothesis
1980-2013	405	-3.705	-3.981*	Fail to reject	405	-12.952	-3.981*	Reject
			-3.421**	Reject			-3.421**	Reject
			-3.133 ***	Reject			-3.133 ***	Reject
1980-1985	70	-2.574	-4.094*	Fail to reject	70	-5.057	-4.094*	Reject
			-3,475**	Fail to reject			-3,475**	Reject
			-3,165***	Fail to reject			-3,165***	Reject
1986-1992	82	-2.812	-4,074 *	Fail to reject	82	-5.982	-4,074 *	Reject
			-3,465**	Fail to reject			-3,465**	Reject
			-3,159***	Fail to reject			-3,159***	Reject
1993-2007	177	-1.561	-4,010 *	Fail to reject	177	-10.555	-4,010 *	Reject
			-3,435**	Fail to reject			-3,435**	Reject
			-3,141***	Fail to reject			-3,142***	Reject
2008-2009	22	-4541	-4,467 *	Reject	22	-2.118	-4,441 *	Fail to reject
			-3,644**	Reject			-3,633**	Fail to reject
			-3,261***	Reject			-3,254***	Fail to reject
2010-2013	45	-1.569	-4,175 *	Fail to reject	45	-5.139	-4,175 *	Reject
			-3,513**	Fail to reject			-3,513**	Reject
			-3,186***	Fail to reject			-3,186***	Reject

*Critical values marked with * are at 1% confidence level/marked with **at 5 % confidence level/marked with *** at 10% confidence level*

CPI - Japan								
Level					First Difference			
Period	Obs	t-statistic	Critical value	Null hypothesis	Obs	t-statistic	Critical value	Null hypothesis
1980-2013	395	-1.471	-3.981*	Fail to reject	395	-3.982	-3.981*	Reject
			-3.421**	Fail to reject			-3.421**	Reject
			-3.133 ***	Fail to reject			-3.133 ***	Reject
1980-1985	70	-4.141	-4.094*	Reject	68	-8.626	-4.094*	Reject

CPI - Japan								
Level					**First Difference**			
Period	**Obs**	**t-statistic**	**Critical value**	**Null hypothesis**	**Obs**	**t-statistic**	**Critical value**	**Null hypothesis**
			-3,475**	Reject			-3,475**	Reject
			-3,165***	Reject			-3,165***	Reject
			-4,078 *	Fail to reject			-4,078 *	Reject
1986-1992	79	-3.011	-3,467**	Fail to reject	79	-7.427	-3,467**	Reject
			-3,160***	Fail to reject			-3,160***	Reject
			-4,010 *	Fail to reject			-4,010 *	Reject
1993-2007	176	-1.961	-3,435**	Fail to reject	176	-11.342	-3,435**	Reject
			-3,141***	Fail to reject			-3,142***	Reject
			-4,440 *	Fail to reject			-4,441 *	Reject
2008-2009	22	-2.836	-3,632**	Fail to reject	22	-4.463	-3,633**	Reject
			-3,254***	Fail to reject			-3,254***	Reject
			-4,170 *	Fail to reject			-4,175 *	Reject
2010-2013	46	-2.236	-3,510**	Fail to reject	45	-5.540	-3,513**	Reject
			-3,185***	Fail to reject			-3,186***	Reject
*Critical values marked with * are at 1% confidence level/marked with **at 5 % confidence level/marked with *** at 10% confidence level*								