



LUND
UNIVERSITY

School of Economics and Management

Purchasing Power Parity (PPP), Sweden before and after EURO times

- Unit Root Test
 - Cointegration Test
-

Masters thesis in Statistics

- Spring 2008

Authors:

Mansoor, Rashid
Smotra, Amit Paul

Advisor:

Prof. Panagiotis Mantalos

Table of contents

1. Abstract.....	4
2. Acknowledgement.....	5
3. Chapter 1: Introduction.....	6
1.1. Problem Discussion.....	7
1.2. Purpose.....	7
1.3. Data.....	7
1.4. Structure of the thesis.....	8
4. Chapter 2: An econometric Evaluation of Purchasing Power Parity	
2.1. Real Exchange Rate.....	9
2.2 Stationarity of Real Exchange Rate.....	10
6. Chapter 3: Unit Roots	
3.1. Introduction.....	11
3.1.1 Augmented Dickey Fuller Test.....	11
3.1.2 Phillips Perron's Test.....	12
7. Chapter 4: Cointegration	
4.1. Introduction.....	13
4.2. Test for cointegration.....	13
4.2.1 Residual Based Test.....	13
4.2.2 Test using Eigen values.....	14
8. Chapter 5: Graphical Presentation of Real Exchange Rate	
5.1 For the Period [Jan1990-Dec1998].....	16
5.2 For the Period [Jan1999-Dec2007].....	18
5.3 For the Period [Jan1990-Dec2007].....	20
9. Chapter 6: Application	
6.1 Application of Unit Root Test to data.....	22
6.2 Application of Cointegration Test.....	24
6.2.1 Residual Based Test.....	24
6.2.1.1 for the period [Jan 1990-Dec1998].....	25
6.2.1.2 for the Period [Jan1999-Dec2007].....	26
6.2.1.3 for the period [Jan1990-Dec2007].....	26

6.2.2 Johansen Test of cointegration.....	26
6.2.2.1 for the Period[Jan1990-Dec1998].....	26
6.2.2.2 for the period[Jan1999-dec2007].....	28
6.2.2.3 for the Period[Jan1990-dec2007].....	30
10. Conclusion.....	31
11. Future Work.....	32
12. References.....	32

Abstract

This thesis presents an Econometric Evaluation of Purchasing Power Parity. Unit Root Test and cointegration Tests are used to examine the issue of the Purchasing Power Parity for Sweden for the Periods [Jan 1990-Dec 1999] , [Jan 1999-Dec 2007] and [Jan1990-Dec2007]. The result of Unit Root tests failed to find evidence in favour of Purchasing Power Parity in all the three periods.

However the result of Johansen test of cointegration finds evidence in favour of Purchasing Power Parity in the long-run.

Keywords: Cointegration, Purchasing Power Parity, Unit Root.

Acknowledgements

A special word of thanks goes to the members of our families for their support and encouragement through out our MSc. Special appreciation goes to our fathers for their unconditional love and financial support.

Chapter 1. Introduction

Purchasing Power Parity involves the study of Exchange Rates and Prices Level across countries. While studying the Econometric Evaluation of the Purchasing Power Parity, two important types of issues arise in the mind. First issue is concerned with the very absence or presence of the PPP. To check the absence and presence of PPP, we study the stationarity and non-stationarity of the real exchange rate. If the real exchange Rate is stationary, it means that PPP holds, otherwise it does not. For this purpose we use the Augment Dickey Fuller Test for the Unit Root. We set the null Hypothesis that the real Exchange Rate is non-stationary, which means the absence of PPP against the alternative hypothesis that the Real Exchange Rate is Stationary, which means the presence of PPP.

We also use the Phillips Perron's Test for structural changes because sometimes the real exchange rate suffers from structural breaks. If the PPP does not hold then the second issue arises, that is the equilibrium relationship of the variables, which is the presence of PPP in the long-run.

To check the presence of PPP in the long run we use cointegration Test. Here we use two type of cointegration test

(1) Residual Based Test (2) Johansen Test

The methods are applied to the exchange rates between Sweden and USA, and their corresponding consumer price indices.

1.1 Problem Discussion

The concept of Purchasing Power Parity was given by Karl Gustav Cassel, a Swedish Economist and Professor at Stockholm University. The theory is based on the law of one price, which states that in an ideal market which is efficient, the cost of identical goods is same. Different countries use different currencies, and ideally the exchange rate between any two currencies should be tailored in such that it equalises the price of identical goods in the two countries. If this happens, then PPP holds.

1.2 Purpose

The purpose of this thesis is to check for the presence or absence of PPP before and after the introduction of Euro currency (1999). Firstly, we check for the stationarity of the 'Real Exchange Rate' before and after the establishment of euro zone and if the real exchange rate is not stationary then we check for the equilibrium relationship between variables and see if there are signs for the presence of PPP in the long run.

1.3 Data

We have used the Exchange Rates between Sweden and USA and the Consumer Price Indices (CPI) of both the countries. The Exchange Rate data is taken from oanda.com. We took reciprocal of the exchange rate of 'USA to Sweden' to obtain the nominal exchange rate of 'Sweden to USA'. The data for CPI of Sweden is taken from the website of Statistiska Centralbyrån and that of USA is taken from the US Department of Labor, Bureau of Labor Statistics. The data is taken from 'January 1990-December 1998' and 'January 1999-December 2007' to account for both post euro and pre euro times.

1.4 Structure of the thesis

This thesis consists of six chapters. A brief overview of each chapter is as follows.

Chapter-1

This introductory chapter has the following aims:

- 1) A general overview of unit root test and cointegration tests regarding PPP.
- 2) A historic and economic overview of PPP.
- 3) About the acquisition of data.

Chapter-2

This chapter consist of two sections. In the first section we have explain the concept of Real exchange Rate and also derived an equation of the Real Exchange Rate.

In the second section we have explain the concept of STATIONARITY and we have also explain the techniques which give us rough idea about the statioarity of Real Exchange Rate and absence or presence of Purchasing Power Parity.

Chapter-3

This chapter give an overview of the concept of Unit Root test. it consist of three section.in the first section we have explain the concept of Unit Root .In the second section we have explain the method of Augmented Dickey Fuller test, Hypothesis Setting and decision Rules. In the third section we have explain the Phillips Perron's Test for structural change.

Chapter-4

This chapter gives us the idea of cointegration Analysis Regarding Purchasing Power Parity. We have explained the concept of cointegration. we have also explain the two cointegration Tests that are Residual Based Test and Test using Eigen values that is Johansen test of cointegration. We have also explained the method of these two tests.

Chapter-5

In this chapter we have checked the stationarty/Non-stationarty of the Real exchange rate through Graphical Presentation. We have used line graphs and correlogram to check the stationarty/Non-Stationarity of Real Exchange Rate.

Chapter-6

In this chapter different unit root tests and cointegration test are applied to check the absence or presence of purchasing power parity.

Chapter 2. An econometric Evaluation of Purchasing Power Parity

2.1 Real Exchange Rate:

Real Exchange Rate is a function of the nominal exchange rate and the ratio of the relative price level between two countries. Nominal exchange rate provides some information regarding measures of the value of one currency in term of another while price levels provides information related to the cost of the basket of commodities for any given country. in other words

$$\text{Real Exchange Rate} = \text{Nominal Exchange Rate} \times \frac{\text{Price level of foreign country}}{\text{Price level of domestic country}}$$

Let

$r_{sek/\$}$ = Real Exchange Rate for Sweden and United State of America

$N_{sek/\$}$ = Nominal Exchange Rate

$P_{\$}$ = Price level of United State of America

P_{sek} = Price level of Sweden

Then we can write

$$r_{sek/\$} = N_{sek/\$} * \frac{P_{\$}}{P_{sek}} \quad (1)$$

Taking Log of equation (1) on both sides we obtain

$$\log r_{sek/\$} = \log N_{sek/\$} + \log P_{\$} - \log P_{sek} \quad (2)$$

Now PPP implies that Nominal Exchange Rate is equal to the difference between in the price level between countries that is

$$\log N_{sek/\$} = \log P_{sek} - \log P_{\$} + e$$

Where “e” represents short term deviation from PPP

$$\rightarrow e = \log N_{sek/\$} + \log P_{\$} - \log P_{sek}$$

Here short run deviation from PPP that is “e” equal to $\log r_{sek/\$}$ that is

$$e = \log r_{sek/\$} = \log N_{sek/\$} + \log P_{\$} - \log P_{sek}$$

Now if “e” is equal to zero then it means that PPP holds.

Let $\log r_{sek/\$} = r_t$, $\log N_{sek/\$} = N_t$, $\log P_{\$} = P_t^{\$}$ and $\log P_{sek} = P_t^{sek}$ then

$$r_t = N_t + P_t^{\$} - P_t^{sek}$$

In the applied work $P_t^{\$}$ and P_t^{sek} refers to the national price indices of USA and Sweden respectively in t relative to a base year.

Long run PPP is said to be hold if the r_t sequence is stationary.

2.2 STATIONARITY

A time-series variables that posses a constant mean and a constant variance over time and the autocorrelation function that depends solely on the length of the expressed lags is known as stationary time series.

If a time series variable satisfy the following properties then it is said to be covariance or weakly stationary:

(1) $E(Y_t) = \mu$, $t = 1,2,3,\dots,\infty$ that is Time Independent Mean [constant for all t]

(2) $Var(Y_t) = \sigma^2$ Time Independent Variance [constant for all t]

(3) $Cov(Y_t, Y_{t-1}) = \gamma_s$ Constant for all t and t-1

So if the Process is covariance Stationary, all the variance are the same and all the covariance depends on the difference between t and t-s.

PPP theory states that if the real exchange rate possesses the above properties then it will be stationary.

The following techniques can be used to get a rough idea of a stationary series.

1) With the help of graphical representation:

A plot of non-stationary series produces a line with definite upward or downward trend with the passage of time. On the other side the stationary time series does not produce such type of line

2) Observing correlogram of autocorrelation function:

For a stationary time-series, the ACFs tend to zero rather quickly while for a non-stationary the ACFs are suffered from linear decline

Chapter 3 - Unit Root Test:

3.1 Introduction

A formal test that can help us in knowing that the given series contains a trend and also give us the information that the trend is deterministic or stochastic. This type of test is known as Unit Root Test. there are several type of Unit Root Test.

The test which we use here is the Augment Dickey Fuller (ADF) test. This test provides a formal test for non-stationary in the time series data. The basic idea behind the Augment Dickey Fuller equation is to test for the presence of Unit Root in the coefficient of lagged variables. If the coefficient of a lagged variable shows a value of one, then the equation show the sign of non-stationary.

3.1.1 Augmented Dickey-Fuller test (Enders, Walter)

To formally test for the presence of a unit root in the real exchange rate, Augmented Dickey-Fuller test of the form given below is carried out:

$$\Delta r_t = a_o + \gamma r_{t-1} + \beta_2 \Delta r_{t-1} + \beta_3 \Delta r_{t-2} + \beta_4 \Delta r_{t-4} + \dots + \epsilon_t$$

The null Hypothesis for the test is

$$H_0 = \gamma = 0 \rightarrow \text{Unit Root Problem}$$

Decision rule:

If t-statistic > ADF critical value => not reject null hypothesis i.e. unit root exists

If t-statistic < ADF critical value => reject null hypothesis, i.e. unit root does not exist.

Here t-statistic is the statistic used in the ADF test.

If the null Hypothesis is accepted, we assume that there is a unit root and difference the data before running a regression. If the null is rejected, the data are stationary and can be used without differencing.

3.1.2 Perron's Test for Structural Change:

I have also applied Perron's test for unit Root. Perron's (1989) goes on to develop a formal test for a unit root in the presence of a structural change at the time period at $t = \tau + 1$

Model under the null Hypothesis:

$$Y_t = a_0 + Y_{t-1} + \mu_1 D_p + e_t$$

Model under the alternative Hypothesis:

$$Y_t = a_0 + a_2 t + \mu_2 D_L + e_t$$

Where $D_p = 1$ if $t = \tau + 1$ and Zero otherwise .

And D_L is level Dummy variable that is 1 if $t > \tau$ and Zero otherwise.

Decision Rule: Reject the null hypothesis of the unit root if the calculated value of the t-statistics is greater than the critical values.

Chapter-4 Cointegration:

4.1 Introduction

Now we move toward cointegration Test of Purchasing Power Parity.

If a series needs to be difference “d” times before it becomes stationary then it contains “d” unit roots and is said to be integrated of order “d” that is I(d).

It is necessary for the cointegration test that the order of integration of all the variables in the long run will be the same. The order of integration is the number of times, a time series variable must be difference for it to become stationary.

According to cointegration method if PPP holds then the sum of the Nominal Exchange Rate and Price level of United States that is $(N_t + P_t^{\$})$ will be cointegrated with Price Level of Sweden (P_t^{sek}) sequence.

Let suppose $Y_t = N_t + P_t^{\$}$

Then PPP asserts that there exists a linear combination of the form $Y_t = \alpha_0 + \alpha_1 P_t^{sek} + e_t$ such that e_t is stationary and the cointegration vector such that $\alpha_1 = 1$. where e_t is the residuals of the regression equation.

4.2 -Testing for cointegration: (Enders, Walter)

4.2.1 Residual Based Test the Engle-Granger Methodology (procedure)

-Test for a Unit Root on Residuals

- ADF Type cointegration Test

- Phillips Perron's Test

-Steps for Residual Based Test

Step-1

Test the variable for their order of cointegration. In the 1st step we determine the order of integration. Here I will use the Augmented Dickey-Fuller Test and Phillips Perron's Test to determine the order of integration.

Step-2

If the result of 1st step indicate that the variable are integrated of order one then estimate the long-run equilibrium relation by regressing $Y_t = N_t + P_t^{\$}$ on P_t^{sek} that is

$$Y_t = \alpha_0 + \alpha_1 P_t^{sek} + e_t$$

Absolute PPP asserts that $Y_t = P_t^{sek}$ so this requires that $\alpha_0 = 0$ and $\alpha_1 = 1$

Step-3

Check the residual of the equilibrium regression for stationary using DF test for Unit root. To determine that the variables are cointegrated we denote the Residual sequence from the equilibrium equation by " \hat{e}_t ". So " \hat{e}_t " is the series of the estimated Residuals of the long run relationship. If the series of the estimated Residuals are found to be stationary then Y_t and P_t^{sek} series will be cointegrated. Estimate the Autoregression of the form:

$$\Delta \hat{e}_t = \beta_1 \hat{e}_{t-1} + \sum_{i=1}^n \beta_{i+1} \Delta \hat{e}_{t-1} + \varepsilon_t$$

If $-2 < \beta_1 < 0$ we can conclude that the Residuals series is stationary and Y_t and P_t^{sek} are integrated of order one that is $C(1, 1)$.

4.2.2- Johansen Test by Using Eigen Values

Test Procedure:

In The Johansen Test Procedure there are two Test Statistics:

- 1) The Trace Statistic and
- 2) The Maximum Eigen Value Statistic

$$1) \text{ Trace Statistic: } \lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

Where $\hat{\lambda}$ = the estimated values of the characteristic roots(also called Eigen values).

T= the number of usable observation

Null Hypothesis: There is at most "r" cointegration relation.

Alternative Hypothesis: There are "m" cointegration relationship (that is series is stationary) $r = 0, 1, 2, \dots, m-1$

Decision Rule: If the trace Statistic is greater than the given critical value then reject the null Hypothesis and conclude that the series is stationary.

(2) The Maximum Eigen Value Statistic = $\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$

Null Hypothesis: There is “r” cointegration relationship

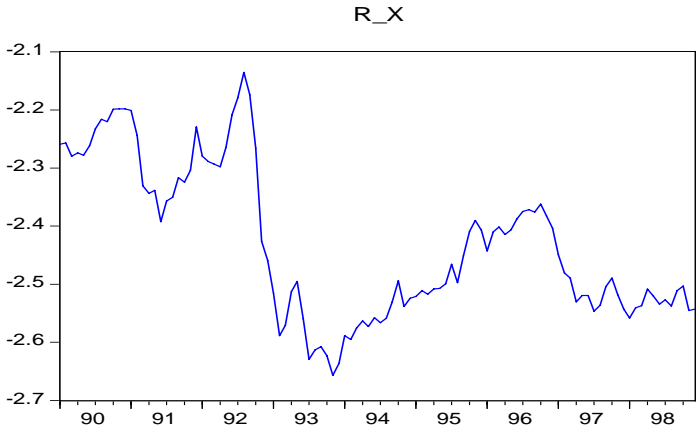
Alternative Hypothesis: there are “r+1” cointegration relationship

Decision Rule: If the Maximum Eigen value Statistic is greater than the given critical value then reject the null Hypothesis and conclude that the series is stationary.

Chapter 5

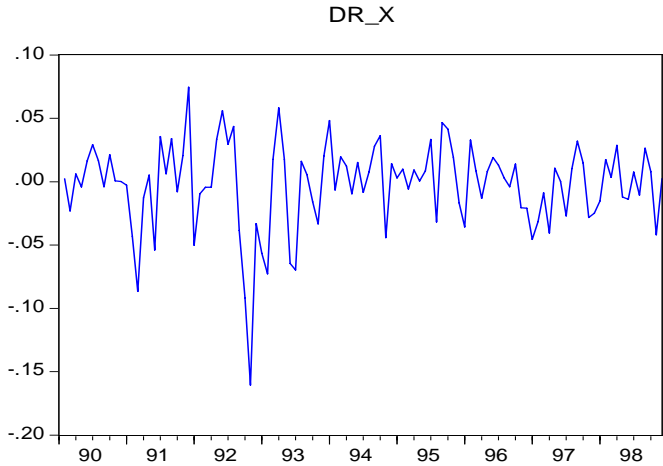
5.1-Graphical Presentation of Real Exchange Rate

From our data for period [Jan 1990-dec 1998] the real exchange rate for Sweden and USA are non-stationary. In the graph the real exchange rate of Sweden and USA shows the strongest upward and downward trends.



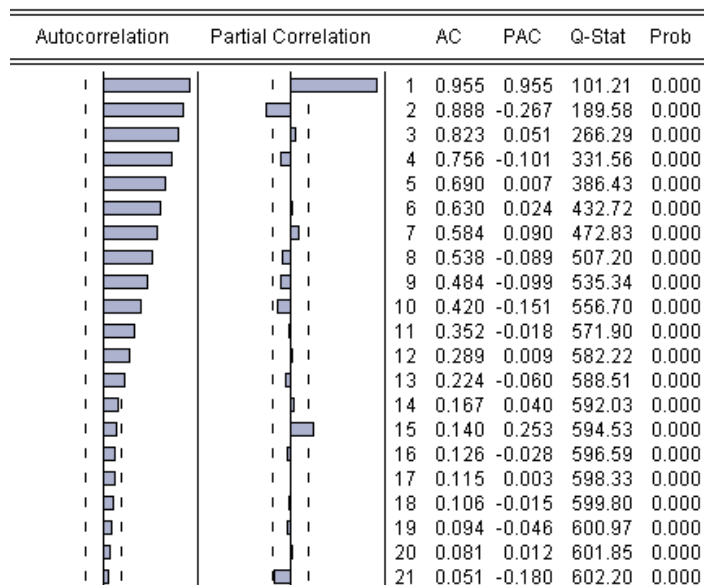
We see that the above graph of real exchange rate is like to have random walk pattern, which random walk up and down in the line graph.

After taking the first difference the Real exchange Rate for the period [Jan 1990-dec 1998] becomes stationary. As we can observe from the line graph.



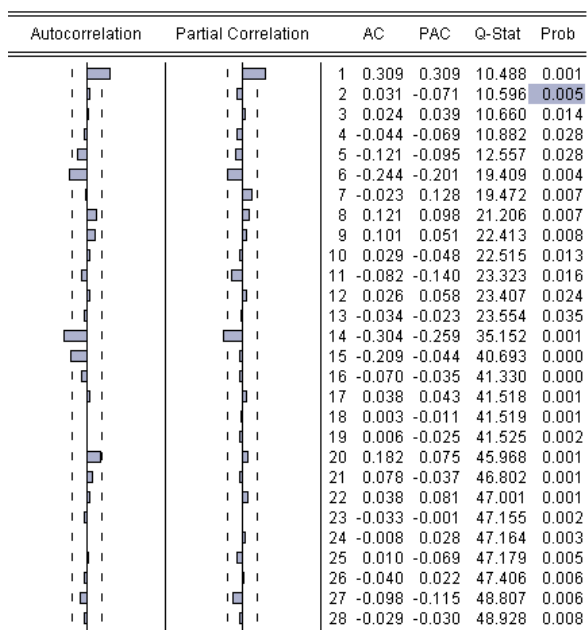
Correlogram of Real Exchange Rate for the Period [Jan1990-Dec1998]

Date: 05/13/08 Time: 23:28
 Sample: 1990M01 1998M12
 Included observations: 108



If we study the Correlogram for this period then there is only one significant spike of PACFs and the ACFs are suffered from linear decline. After taking the first difference the Correlogram looks like.

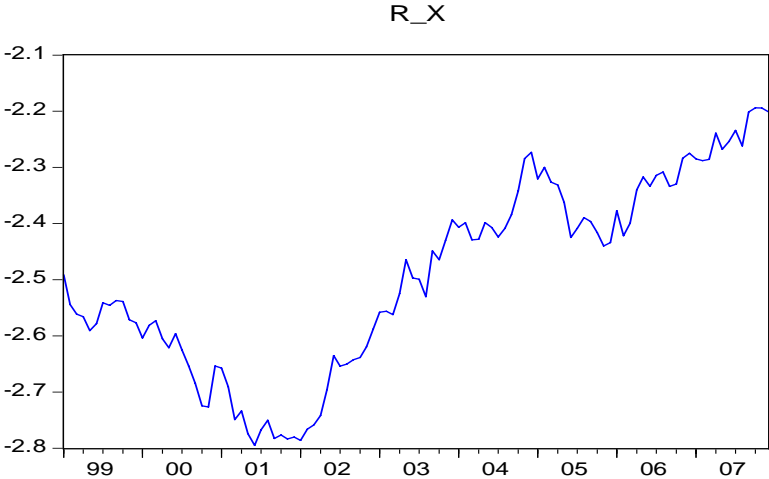
Date: 05/13/08 Time: 23:38
 Sample: 1990M01 1998M12
 Included observations: 107



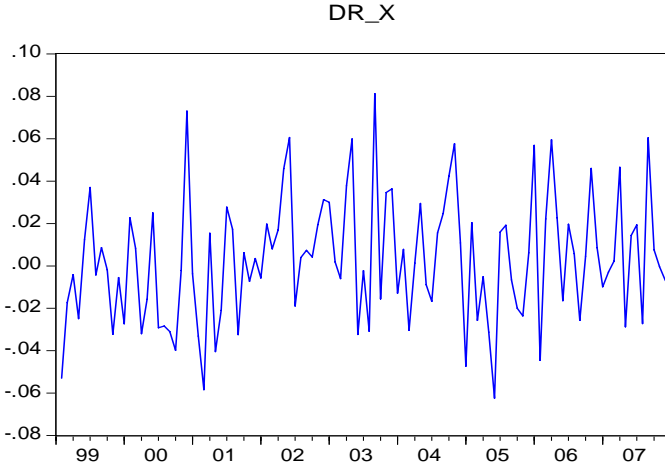
we see that the real exchange rate is now stationary as shown no significant patterns in the graph of the Correlogram.

5.2-Graphical Presentation of Real Exchange Rate.

Similarly for the data for the period [Jan 1999-dec 2007] the line grape of the real exchange rate shows that the real exchange rate after the introduction of Euro is not stationary. The Sweden and USA real exchange rate shows the down ward and upward trend from Jan 1999 to Dec 2007.Similarly if we study the correlogrm, we will see that The ACFs are suffered from linear decline and there is only one significant spike of PACFs.the result is given in Table A.1.2



After taking the first difference the Real Exchange Rate for the period [Jan 1999-dec 2007] Look like.



Correlogram of Real exchange Rate for the Period [Jan1999-Dec2007]

Date: 05/13/08 Time: 23:56
 Sample: 1999M01 2007M12
 Included observations: 108

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.971	0.971	104.70	0.000
		2	0.940	-0.047	203.80	0.000
		3	0.912	0.030	297.93	0.000
		4	0.883	-0.034	386.99	0.000
		5	0.858	0.060	471.88	0.000
		6	0.829	-0.084	551.96	0.000
		7	0.801	0.006	627.44	0.000
		8	0.773	-0.026	698.41	0.000
		9	0.739	-0.106	763.98	0.000
		10	0.710	0.061	825.10	0.000
		11	0.678	-0.082	881.40	0.000
		12	0.641	-0.095	932.22	0.000
		13	0.605	-0.022	977.93	0.000
		14	0.572	0.058	1019.3	0.000
		15	0.542	0.016	1056.8	0.000
		16	0.513	-0.028	1090.8	0.000
		17	0.481	-0.022	1121.0	0.000
		18	0.444	-0.146	1147.1	0.000
		19	0.405	-0.031	1168.9	0.000
		20	0.366	-0.038	1187.0	0.000
		21	0.330	0.019	1201.8	0.000
		22	0.300	0.081	1214.3	0.000
		23	0.277	0.106	1225.1	0.000
		24	0.249	-0.115	1233.8	0.000
		25	0.225	0.058	1241.1	0.000
		26	0.203	0.019	1247.0	0.000
		27	0.180	-0.024	1251.8	0.000
		28	0.158	-0.029	1255.5	0.000

From the above Correlogram we see that the real exchange rate is not stationary during the period [Jan1999-Dec2007] because the ACFs are suffered from linear decline and there is only one significant spike of PACFs. After taking the first difference the correlogram look like as below.

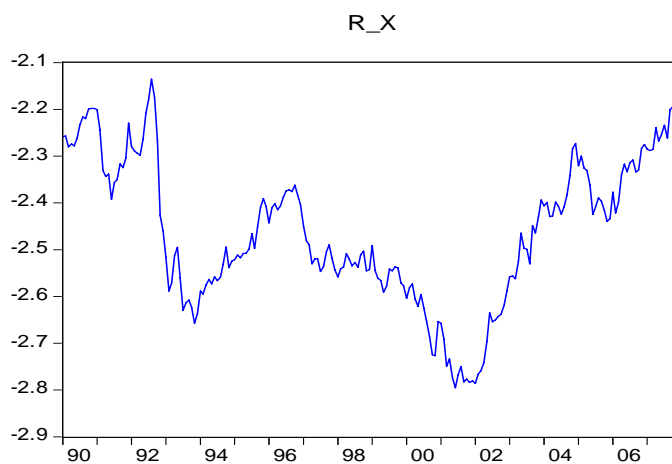
Date: 05/14/08 Time: 00:10
Sample: 1999M01 2007M12
Included observations: 107

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
		1 0.031	0.031	0.1048	0.746
		2 -0.097	-0.098	1.1401	0.566
		3 0.045	0.052	1.3702	0.713
		4 0.045	0.033	1.6018	0.808
		5 0.024	0.031	1.6675	0.893
		6 0.032	0.036	1.7882	0.938
		7 0.036	0.036	1.9392	0.963
		8 0.088	0.089	2.8461	0.944
		9 -0.016	-0.021	2.8784	0.969
		10 0.101	0.116	4.1047	0.943
		11 0.149	0.131	6.8122	0.814
		12 -0.069	-0.065	7.3890	0.831
		13 -0.103	-0.090	8.7157	0.794
		14 0.024	-0.010	8.7894	0.844
		15 0.022	-0.012	8.8513	0.885
		16 -0.046	-0.060	9.1262	0.908
		17 0.217	0.232	15.243	0.578
		18 0.108	0.078	16.781	0.538
		19 -0.059	-0.038	17.247	0.573
		20 -0.040	-0.028	17.457	0.623
		21 -0.055	-0.109	17.863	0.658
		22 -0.141	-0.199	20.576	0.547
		23 0.015	0.034	20.606	0.605
		24 0.033	0.054	20.763	0.653
		25 -0.052	-0.095	21.142	0.685
		26 -0.078	-0.063	22.022	0.687
		27 -0.061	-0.082	22.565	0.708
		28 0.059	-0.041	23.079	0.729

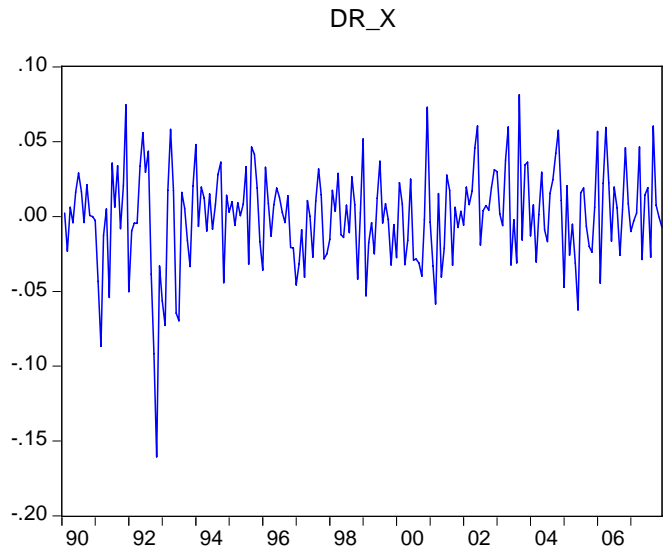
Now the series is stationary as we see that ACFs tend to zero rather quickly.

5.3-Graphical Presentation of Real Exchange Rate for the period [Jan1990-Dec2007].

For this period the Graph of the real exchange rate is not stationary. The graph shows some upward and downward movement during this period. Also there is some Structural breaks during this period. If we look at the Correlogram we see that the ACFs are suffered from linear decline and the is only one significant spike of PACFs.



After taking the first diffence of the Real Exchange Rate. The Graph of the real exchange looks like.



Correlogram of the Real Exchange Rate for the Period [Jan1990-Dec2007]:

The real exchange rate the period[Jan 1990-Dec2007] look like Non-stationary because in the below Correlogram the ACFs are suffered from linear decline and there is only one significant spike of PACFs.

Date: 05/14/08 Time: 00:27
 Sample: 1990M01 2007M12
 Included observations: 216

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob
1	0.968	0.968	205.26	0.000	
2	0.928	-0.147	394.73	0.000	
3	0.890	0.031	569.83	0.000	
4	0.850	-0.064	730.31	0.000	
5	0.813	0.041	877.85	0.000	
6	0.777	-0.033	1013.1	0.000	
7	0.744	0.054	1137.8	0.000	
8	0.712	-0.043	1252.5	0.000	
9	0.674	-0.100	1355.7	0.000	
10	0.634	-0.033	1447.5	0.000	
11	0.592	-0.058	1527.9	0.000	
12	0.548	-0.033	1597.4	0.000	
13	0.505	-0.030	1656.6	0.000	
14	0.467	0.051	1707.4	0.000	
15	0.440	0.142	1752.8	0.000	
16	0.419	0.021	1794.2	0.000	
17	0.398	-0.005	1831.7	0.000	
18	0.374	-0.082	1865.1	0.000	
19	0.348	-0.021	1894.0	0.000	
20	0.322	-0.005	1919.0	0.000	
21	0.293	-0.063	1939.7	0.000	
22	0.266	0.034	1956.8	0.000	
23	0.240	-0.059	1970.8	0.000	
24	0.208	-0.137	1981.4	0.000	
25	0.180	0.046	1989.4	0.000	
26	0.154	-0.019	1995.3	0.000	
27	0.130	0.011	1999.5	0.000	
28	0.107	0.012	2002.3	0.000	

After taking the first difference the Correlogram for real exchange rate for the period[Jan1990-Dec2007] look like.

Date: 05/14/08 Time: 00:33
Sample: 1990M01 2007M12
Included observations: 215

Autocorrelation	Partial Correlation	AC	PAC	Q-Stat	Prob	
		1	0.182	0.182	7.2363	0.007
		2	-0.030	-0.066	7.4367	0.024
		3	0.051	0.071	7.9982	0.046
		4	0.003	-0.023	8.0005	0.092
		5	-0.056	-0.048	8.7037	0.121
		6	-0.100	-0.088	10.939	0.090
		7	0.001	0.034	10.939	0.141
		8	0.105	0.099	13.428	0.098
		9	0.072	0.049	14.617	0.102
		10	0.056	0.041	15.327	0.121
		11	0.025	-0.009	15.476	0.162
		12	-0.011	-0.026	15.503	0.215
		13	-0.061	-0.052	16.352	0.231
		14	-0.151	-0.118	21.673	0.086
		15	-0.099	-0.044	23.937	0.066
		16	-0.052	-0.037	24.565	0.078
		17	0.137	0.167	28.986	0.035
		18	0.037	-0.030	29.317	0.045
		19	-0.033	-0.041	29.582	0.057
		20	0.088	0.058	31.434	0.050
		21	0.009	-0.032	31.453	0.066
		22	-0.011	0.045	31.483	0.087
		23	0.022	0.067	31.598	0.109
		24	0.008	0.022	31.615	0.137
		25	-0.023	-0.047	31.741	0.166
		26	-0.056	-0.061	32.502	0.177
		27	-0.057	-0.074	33.310	0.187
		28	0.021	0.006	33.420	0.221

Chapter 6 Application

6.1- Application of Unit Root Tests to Data:

In our data I have applied both ADF Test and Phillips Perron's Test.

Long run PPP is said to hold if the Real Exchange Rate sequence is stationary. Here I have constructed the Real Exchange Rate for Sweden trading Partner that is USA.the data is divided into three periods [Jan 1990-dec 1998] and [Jan 1991-dec 2007] and [Jan1990-Dec2007].

To get the sequence of Real Exchange Rate (r_t) .I have Multiplied the Consumer Price Indices of USA to the Nominal Exchange Rate of Sweden to Foreign currency and then divided by the Consumer Price Indices of Sweden. The Log of the constructed series is the Real Exchange Rate sequence (r_t).

Using the ADF test and the Monthly Data of the synthetic real krona/dollar Exchange Rate for the Period [Jan 1990-dec 1998], suggest that the real exchange rate is Non-Stationary, suggest that PPP not hold for the give period. In addition I have also applied Perron's test which also find that Real Exchange Rate for the period [Jan 1990-dec 1998] is Non-stationary, suggest that PPP not hold for the given period. The Result is given in TABLE-1

Similarly using the ADF test, Perron's test and the monthly data of synthetic real krona/dollar Exchange Rate for the period [Jan 1999-dec 2007] find that the Real Exchange rate for the given period is Non-stationary, suggest PPP not hold for the given period. The Result is given in TABLE-2

We have also applied the ADF test and Phillips Perron's Test to the real Exchange rate for the period [Jan 1990-Dec2007]. These two test give us the result that the real exchange rate during this period is also Non-stationary. The result is given in Table-3.

After taking the first difference of the variable [Real Exchange Rate] for the period [Jan 1990-Dec 1998] the null hypothesis of unit root can be rejected at 1%, 5% and 10% level of significance using ADF and Phillips Perron's test. The result is given in Table-4

Similarly after taking the first difference of the real exchange rate for the period [Jan 1999-dec 2007] the null hypothesis of unit root is rejected at 1% , 5% and 10% level of significance using ADF and Phillips Perron's test. The result is given in Table-5 and also the real exchange rate for the period [Jan1990-Dec2007] become stationary after taking the first difference of the real exchange rate. Using the ADF test and the Phillips Perron's test the null hypothesis of the unit root is rejected at 1%, 5% and 10% level of significant. The result is given in Table-6.

After a brief study of these three periods that are [Jan 1990-Dec1998] , [Jan1999-Dec2007] and [Jan1990-dec2007] we reach at the decision that Purchasing Power Parity does not hold during these periods.

TABLE -1 Real Exchange Rate for the period(Jan 1990-dec 1998)						
TEST	T-statistic	C.V 1%	C.V 5%	C.V 10%	Null hypothesis	conclusion
ADF	-2.039912	-3.493129	-2.888932	-2.581453	Accept	Non-stationary
Perron's	-1.814025	-3.492523	-2.888669	-2.581313	Accept	Non-stationary

TABLE-2 Real Exchange Rate for the period(Jan 1991-dec 2007)						
TEST	T-statistic	C.V 1%	C.V 5%	C.V 10%	Null hypothesis	conclusion
ADF	-0.053626	-3.492523	-2.888669	-2.581313	Accept	Non-stationary

Perron's	-0.034657	-3.492523	-2.888669	-2.581313	Accept	Non-stationary
----------	-----------	-----------	-----------	-----------	--------	----------------

TABLE -3 Real Exchange Rate for the period(Jan 1990-dec 2007)						
TEST	T-statistic	C.V 1%	C.V 5%	C.V 10%	Null hypothesis	conclusion
ADF	-1.702655	-3.460884	-2.874868	-2.573951	Accept	Non-stationary
Perron's	-1.596789	-3.460739	-2.874804	-2.573917	Accept	Non-stationary

Table-4 after taking 1 st difference Real Exchange Rate for the period(Jan1990-Dec1998)						
TEST	T-statistic	C.V 1%	C.V 5%	C.V 10%	Null hypothesis	conclusion
ADF	-7.411040	-3.493129	-2.888932	-2.581453	Reject	stationary
Perron's	-7.386610	-3.493129	-2.888932	-2.581453	Reject	stationary

TABLE-5 After1 st different Real Exchange for the period(Jan 1991-dec 2007)						
TEST	T-statistic	C.V 1%	C.V 5%	C.V 10%	Null hypothesis	conclusion
ADF	-10.05398	-3.493129	-2.888932	-2.581453	Reject	stationary
Perron's	-10.05378	-3.493129	-2.888932	-2.581453	Reject	stationary

TABLE-6 After1 st different Real Exchange for the period(Jan 1990-dec 2007)						
TEST	T-statistic	C.V 1%	C.V 5%	C.V 10%	Null hypothesis	conclusion
ADF	-12.10828	-3.460884	-2.874868	-2.573951	Reject	stationary
Perron's	-12.12229	-3.460884	-2.874868	-2.573951	Reject	stationary

6.2-Application of cointegration Test to data:

After studying the ADF test and Phillips Perron's Test of Unit Roots we reach at the decision that the real exchange rate for the Periods [Jan 1990-Dec1998] , [Jan 1999-Dec2007] and

[Jan1990-Dec2007] is Non-stationary and Purchasing Power Parity does not hold for these three period.

Now we want to check the presence or absence of Purchasing Power Parity in the long-run. For this purpose we will apply the below cointegration tests.

After studying the consumer price indices of Sweden and USA , and the nominal exchange rate of Sweden , we reach at the decision that all these variables are integrated of order one that is I(1) because the first difference of these variables is stationary that is I(0).

6.2.1-Residual Based Test:

$$Y_t = \alpha_0 + \alpha_1 P_t^{sek} + e_t$$

Absolute PPP asserts that $Y_t = P_t^{sek}$ so this requires that $\alpha_0 = 0$ and $\alpha_1 = 1$

First we have found the equilibrium regression before the introduction of Euro zone that is for the period [jan1990-dec1998].the Result gives us the value of the coefficient that is α_1 and the standards errors are given in table A-1.we see from the table that the value of the estimated coefficient is very below from unity.

Similarly we have found the equilibrium regression after the introduction of the Euro zone that is for the period [jan1999-dec2007].in this case the value of the coefficient is very over unity.

for the Period[Jan1990-Dec2007] we have find the Equilibrium regression and the estimated value of the coefficient is approximately close to unity.

The result is given in Table A-1

Table A-1 Equilibrium Regression					
Period		Period		Period	
Jan1990-dec1998		Jan1999-dec2007		Jan1990-Dec2007	
Estimated α_1	-0.3235	Estimated α_1	4.367524	Estimated α_1	0.599262
Standard Error	.128672	Standard Error	.286219	Standard Error	.123010

Now we want to check the residual of the equilibrium regression for stationarity using Dickey-Fuller test(1979). We estimate Autoregressive of the form

$$\Delta \hat{e}_t = \beta_1 \hat{e}_{t-1} + \sum_{i=1}^n \beta_{i+1} \Delta \hat{e}_{t-1} + \varepsilon_t$$

If $-2 < \beta_1 < 0$ we can conclude that the Residuals series is stationary and Y_t and P_t^{sek} are integrated of order one that is $C(1, 1)$.

To check the residual of the equilibrium regression for the period [jan1990-dec1998], [Jan1991-Dec2007] and [jan1990-Dec2007], we will use the Dickey-fuller test statistic and compare its value with the critical values for the Engle-Granger cointegration Test.

Null hypothesis: No cointegration

6.2.1.1-For the period [Jan1990-Dec1998]:

The Dickey-Fuller Test statistic value (-2.193780) is greater than the critical values (-4.008, -3.398, -3.087) at 1%, 5% and 10% level of significance respectively so we can not reject the null hypothesis of No cointegration and conclude that Y_t and P_t^{sek} are not cointegrated. Table- A2

6.2.1.2-For the Period [Jan1999-Dec2007]:

The Dickey-Fuller Test statistic value (-0.821506) is greater than the critical values (-4.008, -3.398, -3.087) at 1%, 5% and 10% level of significance respectively so we can not reject the null hypothesis of No cointegration and conclude that Y_t and P_t^{sek} are not cointegrated. Table- A2.

6.2.1.3-For the Period [Jan1990-Dec2007]:

The Dickey-Fuller Test statistic value (-1.345772) is greater than the critical values (-3.921, -3.50, -3.054) at 1%, 5% and 10% level of significance respectively so we can not reject the null hypothesis of No cointegration and conclude that Y_t and P_t^{sek} are not cointegrated. Table- A2.

Table-A2		Residual Based Test		
Dickey-Fuller Test –statistic		Critical values for Engle-Granger cointegration Test(Two variables)		
Period	t-stat. values	C.V 1%	5%	10%
Jan1990-Dec1998	-2.193780	-4.008	-3.398	-3.087
Jan 1999-Dec2007	-0.821506	-4.008	-3.398	-3.087

Jan1990-Dec2007	-1.345772	-3.921	-3.350	-3.054

6.2.2-Johansen Test of cointegration

6.2.2.1-For the period [Jan1990-dec1998]

The result of the Johansen test is quite sensitive to the lag length. So to select the suitable Lag length for your cointegration test we will first find a suitable Var Model using the undifferenced data and then we will use the same Lag length for our cointegration test.

Selection of appropriate Var model:

TO select an appropriate lag order for our VAR model, we have estimate a range of VARS with 1 to 8 lags and tabulated AIC and SIC values. The result is as follow:

Table -A3		
NUMBER OF LAGS	SCHWARZ	Akaike information criteria
1	-21.18486	-21.48462
2	-21.07589	-21.60355
3	-20.97101	-21.72928
4	-20.79421	-21.78586
5	-20.41303	-21.64087
6	-20.14714	-21.61404

From the above table SCHWARZ has selected 1 lags VAR and AKAIKE has selected four lag VAR.

So we select four lag VAR because if we select one lag VAR then their some autocorrelation problem at different lags. We0 have checked autocorrelation LM test for one LAG VAR. So we will use lag four for our cointegration test.

Here we use Eviews-6 Programme which automatically selects suitable lags for Johansen cointegration test.

Now we want to procede to the Johansen Test of cointegration.

-- Johansen Test

Johansen Test Procedure:

(1) The Trace Statistic:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

$$\lambda_{trace}(0) = -T[\ln(1 - \lambda_1) + \ln(1 - \lambda_2) + \ln(1 - \lambda_3)]$$

$$= -103[\ln(1-0.1985) + \ln(1-.0512) + \ln(1-.00385)]$$

$$= 28.6016$$

So the $\lambda_{trace}(0) = 28.6016$ is greater than the critical values [24.27596, 21.77716] at 5% and 10% level of significant respectively, so we reject the null hypothesis of no cointegration vector and accept the alternative hypothesis of one or more cointegration vector. Also $\lambda_{trace}(1) = 5.8127$ Which is less than the critical values [12.32090, 10.47457] at 5% and 10% level of significant respectively so we can not reject the null hypothesis of no more than cointegration vectors.

Similarly $\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$

$$\lambda_{max}(0,1) = -103 * \ln(1 - \hat{\lambda}_1)$$

$$\lambda_{max}(0,1) = -103 * \ln(1-0.1985)$$

$$\lambda_{max}(0,1) = 22.7908$$

So the value of $\lambda_{max}(0,1) = 22.7908$ is greater than the critical values [17.79730, 15.71741] so we reject the null hypothesis of no cointegration vector and accept the alternative hypothesis of one cointegration vector. Similarly $\lambda_{max}(1,2) = 5.4154$ is less than the critical values [11.22480, 10.47457] at 5% and 10% level of significance respectively, so we accept the null hypothesis of one cointegration vector and reject the alternative hypothesis of two cointegration vector.

After studying Johansen Test of cointegration, we reach at the decision that there is only one cointegration vector and we can say that for the period [Jan1990-Dec 1998] the cointegration hold and find in favour of PPP.

Table-A4 λ_{trace} and λ max Statistic							
Statistic	Null Hypothesis	Alternative Hypothesis	Eigen values	Test-statistic value.	5% critical value	10% critical value	Null hypoth:
λ_{trace} statistic	r = 0	r > 0	0.198517	28.60582	24.27596	21.77716	Reject
	r ≤ 1	r > 1	0.051219	5.812747	12.32090	10.47457	Accept
	r ≤ 2	r > 2	0.003850	0.397304	4.129906	2.976163	Accept
λ max statistic	r = 0	r = 1	0.198517	22.79308	17.79730	15.71741	Reject
	r = 1	r = 2	0.051219	5.415443	11.22480	10.47457	Accept
	r = 2	r = 3	0.003850	0.397304	4.129906	2.976163	Accept

6.2.2.2-Johansen Test of cointegration for the period [Jan1999-dec2007].

The Trace Statistic:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

$$\begin{aligned} \lambda_{trace}(0) &= -T[\ln(1 - \lambda_1) + \ln(1 - \lambda_2) + \ln(1 - \lambda_3)] \\ &= -103[\ln(1 - .2821) + \ln(1 - .1231) + \ln(1 - .00018)] \\ &= 47.6856 \end{aligned}$$

So the $\lambda_{trace}(0) = 47.6856$ is greater than the critical values [24.27596, 21.77716] at 5% and 10% level of significant respectively, so we reject the null hypothesis of no cointegration vector and accept the alternative hypothesis of one or more cointegration vector. Also $\lambda_{trace}(1) = 13.5529$ Which is greater than the critical values [12.32090, 10.47457] at 5% and 10% level of significant respectively so we can reject the null hypothesis of no more than cointegration vectors. The result is given in Table-A5

Similarly $\lambda_{max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1})$

$$\lambda_{max}(0,1) = -103 * \ln(1 - \hat{\lambda}_1)$$

$$\lambda_{max}(0,1) = -103 * \ln(1 - .282141)$$

$\lambda_{max}(0,1) = 34.1427$ which is greater than the critical values [17.79730, 15.71741] at 5% and 10% level of significance, so we reject the null hypothesis of no cointegration and accept the alternative hypothesis of one cointegration vector.

Similarly $\lambda_{max}(1,2) = 13.5347$ which is greater than the critical values [11.22480, 9.474804] at 5% and 10% level of significance so we reject the null hypothesis of one cointegration vector and accept the alternative hypothesis of two cointegration vector. The result is given in table-A5.

Table-A5 λ_{trace} and λ max Statistic	
--	--

Statistic	Null Hypothesis	Alternative Hypothesis	Eigen values	Test-statistic value.	5% critical value	10% critical value	Null hypoth:
λ_{trace} statistic	$\mathbf{r = 0}$ $r \leq 1$ $r \leq 2$	$\mathbf{r > 0}$ $r > 1$ $r > 2$	0.282141 0.123138 0.000176	47.69565 13.55293 0.018179	24.27596 12.32090 4.129906	21.77716 10.47457 2.97616	Reject Reject Accept
λ max statistic	$\mathbf{r = 0}$ $r = 1$ $r = 2$	$\mathbf{r = 1}$ $r = 2$ $r = 3$	0.282141 0.123138 0.000176	34.14273 13.53475 0.018179	17.79730 11.22480 4.129906	15.71741 9.474804 2.976163	Reject Reject Accept

After studying the Johansen test of cointegration for the period [Jan1999-Dec2007] we reach at the decision that there are two cointegration relationship which support the presence of Purchasing Power Parity in the long-run.

6.2.2.3- Johansen Test of cointegration for the period [Jan1990-dec2007]:

The Trace Statistic:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^n \ln(1 - \hat{\lambda}_i)$$

$$\begin{aligned} \lambda_{trace}(0) &= -T[\ln(1 - \lambda_1) + \ln(1 - \lambda_2) + \ln(1 - \lambda_3)] \\ &= -211 * [\ln(1 - 0.1994) + \ln(1 - 0.0188) + \ln(1 - 0.00000615)] \\ &= 50.9354 \end{aligned}$$

So the $\lambda_{trace}(0) = 50.9354$ is greater than the critical values [24.2759, 21.7771] at 5% and 10% level of significant respectively, so we reject the null hypothesis of no cointegration vector and accept the alternative hypothesis of one or more cointegration vector.

Similarly $\lambda_{max}(r, r + 1) = -T \ln(1 - \hat{\lambda}_{r+1})$

$$\begin{aligned} \lambda_{max}(0,1) &= -211 * \ln(1 - \hat{\lambda}_1) \\ \lambda_{max}(0,1) &= -211 * \ln(1 - 0.1994) \end{aligned}$$

$\lambda_{max}(0,1) = 46.9251$ So the value of $\lambda_{max}(0,1) = 46.9251$ is greater than the critical values [24.2759, 21.7771].

So we reject the null hypothesis of no cointegration vector and accept the alternative hypothesis of one cointegration vector. The result is given in Table-A6

Table-A6 λ_{trace} and λ max Statistic							
Statistic	Null Hypothesis	Alternative Hypothesis	Eigen values	Test-statistic value.	5% critical value	10% critical value	Null hypoth:
λ_{trace} statistic	$\mathbf{r = 0}$ $r \leq 1$ $r \leq 2$	$\mathbf{r > 0}$ $r > 1$ $r > 2$	0.199448 0.018845 6.15E-06	50.95330 4.015594 0.001298	24.27596 12.32090 4.129906	21.77716 10.47457 2.976163	Reject Accept Accept
λ max statistic	$\mathbf{r = 0}$ $r = 1$ $r = 2$	$\mathbf{r = 1}$ $r = 2$ $r = 3$	0.199448 0.018845 6.15E-06	46.93770 4.014295 0.001298	17.79730 11.22480 4.129906	15.71741 9.474804 2.976163	Reject Accept Accept

After studying the Johansen test of cointegration we reach at the decision that there is only one cointegration relationship between variables and there is a sign of the presence of Purchasing Power Parity in the long-run.

Conclusion:

This thesis is concern with the absence or presence of purchasing power parity for Sweden before and after the introduction of Euro. The Sweden is taken as domestic country and united state of America is taken as foreign country. To check the absence or presence of the purchasing power parity two different test methods are used. The first method is concern with the unit root tests. In this method to check the absence or presence of PPP we check the statioarity and Non-stationarty of the real exchange rate. If the real exchange rate is stationary, it mean PPP hold otherwise do not hold. For this purpose we have used two different types of unit root tests that ADF test and Phillips Perron's test. Both of these test has failed to find evidence in favour of purchasing power parity.

The other test method which we have used is the cointegration test. The result of this test is encouraging and provides evidence of Purchasing Power Parity in the long run. The residual based test and the Johansen test of cointegration are used.

The Johansen Trace statistic test and maximum Eigen value statistic test are used.

Both the tests have rejected the null hypothesis of no cointegration and these tests provide evidence in favour of Purchasing Power parity in the long-run.

Using these test we found that there is only one cointegration relationship for the period [Jan1990-Dec1998], two cointegration relationships among variables for the period [Jan1999-Dec2007] and one cointegration relationship among variables for the period [Jan1990-Dec2007].

It can be therefore concluded that there is strong long run relation among the exchange rates and the price indices and the three variables will stay close to each other in the long run.

Future work:

Exchange rates constitute a very cardinal component of global economy which supports the international transaction between corporates, nation states and individuals. Exchange rates measure the value of one currency against the other. It is considered very important by respective governments, banks and other financial institutions which are involved extensively into the international scale transactions. The global trading volume per day is in the range of trillions of US dollars and even small fluctuation in the exchange rate can have big effect on the financial transactions. Thus it is very important to understand the mechanism of the exchange rates, and its volatility. This thesis can be extended in future to cover modelling of exchange rates volatility using the ARCH and GRACH models.

References:

- 1) Perron, P., (1989), “The Great Crash, the Oil Price Shock and the Unit Root Hypothesis,” *Econometrica*, 57, 1361–1401.
- 2) David A. Dickey and Wayne A. Fuller (June, 1979)
“Distribution of the Estimators for autoregressive Time Series With a Unit Root”,
Journal of the American Statistical Association, Vol. 74, No. 366, pp. 427-431
- 3) Enders Walter, *Applied Econometric Timeseries*, Wiley, 2nd Edition, 2004