MONASH UNIVERSITY
DEPT OF ECONOMETRICS AND BUSINESS STATISTICS

ASSESSMENT COVER SHEET

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Unit name	Applied Econometrics	**Unit code**	ETF3200

Note: If this is a group assignment, please include the names of all other group members.

Title of assignment	**Assignment 2**
Lecturer/tutor	Vasilis Sarafidis/Quang Bui
Is this an authorised group assignment? ☐ **Yes** ☒ **No**	
Has any part of this assignment been previously submitted as part of another unit/course? ☐ **Yes** ☒ **No**	
Tutorial/laboratory day & time	Thursday 11am
Due date 07/05/18	**Date submitted 06/05/18**

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Extension granted until (date) .... **Signature of lecturer/tutor** ....

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Part 1.1

Purchasing Power Parity is the economic theory that if goods market arbitrage enforces broad parity in prices across a large range of individual goods then there should be a high correlation in aggregate price levels. It allows economists and non-economists alike to compare prices between countries with different currencies. Many people believe in a version of PPP that is an anchor for long run real exchange rates.

In practice PPP does not regularly hold, and as such there are often opportunities of arbitrage across markets. Specifically, the speed of convergence to PPP is often slow, and PPP itself is extremely volatile in the short run. In fact, it shares the same level of conditional volatility as nominal exchange rates.

PPP was born out of the financial system collapse during WW1. The pegging of the value of a currency to gold had led to highly volatile currency as it was extremely difficult to manage the gold standard. To solve the problem, Swedish economist Gustav Cassel, promoted the use of PPP to set relative gold parities. Cassel highlighted that by calculating the cumulative CPI inflation rates and using inflation differentials to calculate the exchange rate changes, the world can effectively maintain PPP.

The most important economic feature of PPP is that for PPP to hold in the long run, the real exchange rate should equal to 1. This implies that in the long run, prices around the world will be equal and that the currency of country A should be able to buy the same number of goods and services in country B as it does in Country A. Further, there are several different representations of PPP that we must highlight to fully understand the features and implications of PPP.

LOOP (Law Of One Price)

LOOP suggests that for any good i:

$$\boldsymbol{P_i = EP_i^*}$$

Where $P_i$is the domestic currency price of good i. P_i^* is the foreign currency price and E is the exchange rate of the home currency for the foreign currency. The theory behind LOOP is that once foreign prices are converted to a common currency (home currency), the said good should sell for the same price in all countries. However, it is important to note that in reality LOOP only holds in theory, not in practice. LOOP is always in breach as a result of trade tariffs and other trade related costs.

Relative Purchasing Power Parity (RPPP)

$$\boldsymbol{\frac{\sum p_{it}}{\sum P_{it-1}} = (\frac{E_t}{E_{t-1}})(\frac{\sum P_{it}^*}{\sum P_{it-1}^*})}$$

RPPP is a succinct economic theory that predicts the relationship between the inflation rates of two countries over a specific period and the movement in the exchange rate between two currencies over the same period. Further, RPPP only requires that the rate of growth in the exchange rate offsets the difference between the rate of growth and foreign price indices.

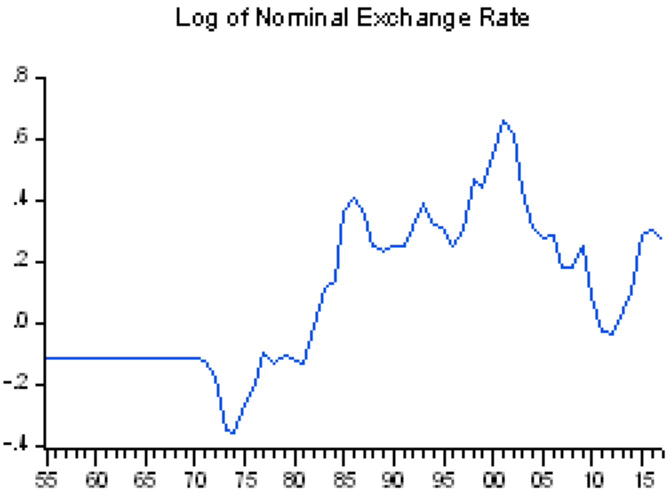
Absolute Purchasing Power Parity (APPP)

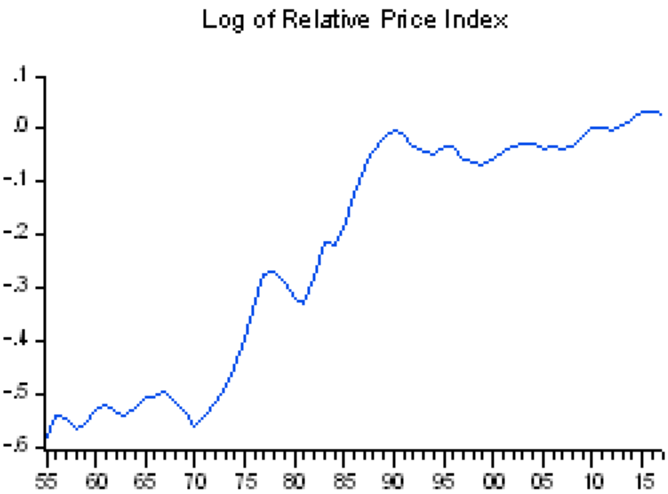
$$\boldsymbol{\sum P_i = E\sum P_i^*}$$

The theory of APPP illustrates the exchange rate between two countries will be the same ratio between the price levels of those two countries. APPP has historically been quite difficult to measure, but Summers and Heston have suggested an innovative theory known as International Comparison

Programme (ICP) to help obtain estimates of APPP. However, ICP is limited in that data for the model is collected infrequently and the coverage of country data is quite limited.

Part 1.2





Empirical research dictates that a time series (X_t)is stationary if it exhibits the following conditions:

- E(Xt) is constant over time
- Var(Xt) is constant over time
- Cov(Xt,X_{t-tau}) is constant over time and tau≠0

Although the last condition is not apparent when time series is graphed, the first two conditions can easily be analysed through observation. Firstly, if we look at the log representation of the Nominal Exchange Rate (NER) we see that the data appears to follow a clear trend upward. Further, we see that the variance in the data appears to change over time. For example, even though there appeared to be no variance from 1955 to 1970, the data appears to vary quite significantly from 1970 onwards. These key characteristics of the data would suggest that the mean (E(xt)) is not constant but actually changes over time. Similarly, the presence of oscillating variation in the data suggests that the variance (Var(Xt)) is not constant over time. Thus, the violation of these two conditions infers that the time series log(nominal exchange rate) could be non-stationary.

Secondly, by analysing the graphical representation of log(RPI) we can clearly see that a positive upward trend is present in the data. However, unlike log(Nominal exchange rate) it's difficult to determine if the variance is changing or constant overtime. Nonetheless, the presence of a positive upward trend suggests that the mean of log(RPI) is not constant over time. Thus this would also infer that the data may not be stationary.

Thus, as we have observed key symptoms of nonstationary time series, we must now conduct ADF and KPSS tests to further conclude if these two time series samples are in fact non stationary.

Part 1.3
At level

Null Hypothesis: LNRPI has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 2 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-1.231257	0.8946
Test critical values:	1% level	-4.118444	
	5% level	-3.486509	
	10% level	-3.171541	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNRPI)
Method: Least Squares
Date: 04/27/18 Time: 11:41
Sample (adjusted): 1958 2017
Included observations: 60 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNRPI(-1)	-0.037813	0.030711	-1.231257	0.2235
D(LNRPI(-1))	0.821731	0.119060	6.901806	0.0000
D(LNRPI(-2))	-0.332392	0.124029	-2.679945	0.0097
C	-0.014840	0.019922	-0.744869	0.4595
@TREND("1955")	0.000353	0.000392	0.900010	0.3720

R-squared	0.484649	Mean dependent var	0.009570
Adjusted R-squared	0.447168	S.D. dependent var	0.023261
S.E. of regression	0.017295	Akaike info criterion	-5.197144
Sum squared resid	0.016451	Schwarz criterion	-5.022615
Log likelihood	160.9143	Hannan-Quinn criter.	-5.128876
F-statistic	12.93082	Durbin-Watson stat	1.862187
Prob(F-statistic)	0.000000		

Null Hypothesis: LNNER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-2.401434	0.3752
Test critical values:	1% level	-4.115684	
	5% level	-3.485218	
	10% level	-3.170793	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNNER)
Method: Least Squares
Date: 04/27/18 Time: 11:39
Sample (adjusted): 1957 2017
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LNNER(-1)	-0.127684	0.053170	-2.401434	0.0196
D(LNNER(-1))	0.380725	0.122838	3.099393	0.0030
C	-0.020431	0.022540	-0.906393	0.3685
@TREND("1955")	0.001127	0.000732	1.540506	0.1290

R-squared	0.182983	Mean dependent var	0.006219
Adjusted R-squared	0.139982	S.D. dependent var	0.079557
S.E. of regression	0.073779	Akaike info criterion	-2.312164
Sum squared resid	0.310269	Schwarz criterion	-2.173746
Log likelihood	74.52101	Hannan-Quinn criter.	-2.257917
F-statistic	4.255334	Durbin-Watson stat	1.932215
Prob(F-statistic)	0.008813		

Ln(RPI) (Level)
Dickey Fuller regression

$$\Delta\ln(RPI) = \beta_0 + \beta_1 \log(RPI_{t-1}) + \delta_1 \Delta\log(RPI_{t-1}) + \delta_2 \Delta\log(RPI_{t-2}) + \beta_2 t + \epsilon_t$$

$$\widehat{\Delta RPI} = -0.0148 - 0.0378\,\Delta\log(RPI_{t-1}) + 0.8217\Delta\log(RPI_{t-1}) - 0.3324\Delta\log(RPI_{t-2}) + 0.0004t$$

(se) (0.01992) (0.0307) (0.1191) (0.1240) (0.000392)

$$H_0: \delta_0 = 0\ (ie\ p = 1\ Y_t\ is\ not\ stationary)$$
$$H_1: \delta_0 < 0\ (ie\ p < 1\ Y_t\ is\ stationary)$$

P value=0.8946

Decision rule: reject H_0 if P value<0.05

Given that P value >0.05 we fail to reject H_0 at the 5% level of significance and conclude that there is not enough evidence from the sample to suggest that the relative price index is stationary at I(0).

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Ln(Nominal Exchange Rate) (level)

Dickey Fuller regression

$$\Delta \ln(ner) = \beta_0 + \beta_1 \ln(ner_{t-1}) + \delta_1 \Delta \ln(ner_{t-1}) + \beta_2 t + \epsilon_t$$

$$\Delta \widehat{\ln(ner)} = -0.0204 - 0.1277 \ln(ner_{t-1}) + 0.3807 \ln(\Delta ner_{t-1}) + 0.0011t$$

(se) (0.0225) (0.0532) (0.1228) (0.0007)

$$H_0: \delta = 0 \ (ie\ p = 1\ Y_t\ is\ not\ stationary)$$
$$H_1: \delta < 0 \ (ie\ p < 1\ Y_t\ is\ stationary)$$

P value=0.3752

Decision rule: reject H_0 if P value<0.05

Given that if P value>0.05 we fail to reject H_0 at the 5% level of significance and conclude that there is not enough evidence from the sample to suggest that the log(Nominal Exchange Rate) is stationary at I(0).

1st difference

Null Hypothesis: D(LNRPI) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.085639	0.0005
Test critical values:	1% level	-4.118444	
	5% level	-3.486509	
	10% level	-3.171541	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNRPI,2)
Method: Least Squares
Date: 04/27/18 Time: 16:08
Sample (adjusted): 1958 2017
Included observations: 60 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNRPI(-1))	-0.553874	0.108910	-5.085639	0.0000
D(LNRPI(-1),2)	0.380491	0.118257	3.217482	0.0022
C	0.008917	0.004984	1.789098	0.0790
@TREND("1955")	-0.000103	0.000130	-0.790691	0.4325

R-squared	0.325853	Mean dependent var	4.70E-05
Adjusted R-squared	0.289738	S.D. dependent var	0.020616
S.E. of regression	0.017374	Akaike info criterion	-5.203286
Sum squared resid	0.016905	Schwarz criterion	-5.063663
Log likelihood	160.0986	Hannan-Quinn criter.	-5.148672
F-statistic	9.022638	Durbin-Watson stat	1.875951
Prob(F-statistic)	0.000057		

Null Hypothesis: D(LNNER) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.474764	0.0001
Test critical values:	1% level	-4.115684	
	5% level	-3.485218	
	10% level	-3.170793	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(LNNER,2)
Method: Least Squares
Date: 04/27/18 Time: 15:57
Sample (adjusted): 1957 2017
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(LNNER(-1))	-0.683054	0.124764	-5.474764	0.0000
C	0.006251	0.020402	0.306407	0.7604
@TREND("1955")	-6.76E-05	0.000558	-0.121059	0.9041

R-squared	0.340825	Mean dependent var	-0.000501
Adjusted R-squared	0.318095	S.D. dependent var	0.092944
S.E. of regression	0.076751	Akaike info criterion	-2.248575
Sum squared resid	0.341660	Schwarz criterion	-2.144761
Log likelihood	71.58153	Hannan-Quinn criter.	-2.207889
F-statistic	14.99441	Durbin-Watson stat	1.891252
Prob(F-statistic)	0.000006		

Ln(RPI) (1st difference)

$$\Delta^2 \ln(RPI_t) = \beta_0 + \delta_0 \Delta(RPI_{t-1}) + \delta_1 \Delta^2 \ln(RPI_{t-1}) + \beta_1 t + \epsilon_t$$

$$\Delta^2 \widehat{\ln(RPI_t)} = 0.0089 - 0.5539\Delta(RPI_{t-1}) + 0.3805\Delta^2 \ln(RPI_{t-1}) - 0.0001t$$

(se) (0.1089) (0.1183) (0.004984) (0.0001)

$$H_0: \delta_0 = 0 \ (ie\ p = 1\ Y_t\ is\ not\ stationary)$$
$$H_1: \delta_0 < 0 \ (ie\ p < 1\ Y_t\ is\ stationary)$$

Pvalue=0.0005

Decision rule: reject H_0 if Pvalue<0.05

Given that Pvalue <0.05 we reject H_0 at the 5% level of significance and conclude that there is enough evidence from the sample to suggest that the log of the relative price index is stationary at I(1).

Ln(Nominal Exchange Rate) (1st difference)

$$\Delta^2 \ln(lnner_t) = \beta_0 + \delta_0 \Delta \ln(lnner_t) + \beta_1 t + \epsilon_t$$
$$\Delta^2 \widehat{\ln(lnner_t)} = 0.0063 - 0.6831 \Delta \ln(lnner_t) - 6.76E^{-05} t$$

(se) (0.0204) (0.1248) (0.0006)

$$H_0: \delta = 0 \ (ie\ p = 1\ Y_t\ is\ not\ stationary)$$
$$H_1: \delta < 0 \ (ie\ p < 1\ Y_t\ is\ stationary)$$

P value=0.001

Decision rule: reject H_0 if P value <0.05

Given that if P value<0.05 we reject H_0 at the 5% level of significance and conclude that there is enough evidence from the sample to suggest that the log(Nominal Exchange Rate) is stationary at I(1).

Through testing for the presence of a unit root at level and first difference, we are able to conclude that at level, the Nominal exchange rate and Relative RPI time series exhibit non-stationarity. However, by testing the data again after first differencing, we find that that both the Nominal exchange rate and Relative price index are both stationary. This infers that we cannot use the data initially as given, but first have to difference the data before it can be used for hypothesis testing.

Part 1.4

Null Hypothesis: RPI is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.164181
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.005991
HAC corrected variance (Bartlett kernel)	0.033370

KPSS Test Equation
Dependent Variable: RPI
Method: Least Squares
Date: 04/26/18 Time: 11:22
Sample: 1955 2017
Included observations: 63

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.592685	0.019587	-30.25966	0.0000
@TREND("1955")	0.011652	0.000545	21.38059	0.0000

R-squared	0.882269	Mean dependent var	-0.231470
Adjusted R-squared	0.880339	S.D. dependent var	0.227391
S.E. of regression	0.078659	Akaike info criterion	-2.216150
Sum squared resid	0.377425	Schwarz criterion	-2.148114
Log likelihood	71.80872	Hannan-Quinn criter.	-2.189391
F-statistic	457.1298	Durbin-Watson stat	0.088117
Prob(F-statistic)	0.000000		

Null Hypothesis: LNNER is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 6 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.122492
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.032362
HAC corrected variance (Bartlett kernel)	0.161138

KPSS Test Equation
Dependent Variable: LNNER
Method: Least Squares
Date: 04/26/18 Time: 11:24
Sample: 1955 2017
Included observations: 63

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.187599	0.045523	-4.120966	0.0001
@TREND("1955")	0.009060	0.001267	7.152687	0.0000

R-squared	0.456139	Mean dependent var	0.093259
Adjusted R-squared	0.447223	S.D. dependent var	0.245893
S.E. of regression	0.182819	Akaike info criterion	-0.529411
Sum squared resid	2.038787	Schwarz criterion	-0.461375
Log likelihood	18.67644	Hannan-Quinn criter.	-0.502652
F-statistic	51.16093	Durbin-Watson stat	0.186549
Prob(F-statistic)	0.000000		

Ln(RPI) (level)

$$H_0: \sigma_u^2 = 0$$
$$H_1: \sigma_u^2 \neq 0$$

Given that the critical values for $DF_{critical}$ statistic are:

1%: 0.216
5%: 0.146
10%: 0.119

Our LM statistic is 0.1642

Decision rule: reject H_0 if LM statistic> $DF_{5\%\ critical}$

Given that if LM statistic > $DF_{5\%\ critical}$, we reject H_0 at the 5% level of significance and conclude that there is enough evidence from the sample to suggest that the RPI is not stationary at level.

Ln(NER) (level)

$$H_0: \sigma_u^2 = 0$$
$$H_1: \sigma_u^2 \neq 0$$

Given that the critical values for $DF_{critical}$ statistic are:

1%: 0.216
5%: 0.146
10%: 0.119

Our LM statistic is 0.12249

Decision rule: reject H_0 if LM statistic> $DF_{5\%\ critical}$

Given that if LM statistic < $DF_{5\%\ critical}$, we fail to reject H_0 at the 5% level of significance and conclude that there is evidence from the sample to suggest that the Ln(NER) is stationary.

Null Hypothesis: D(LNRPI) is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 3 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.094326
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.000527
HAC corrected variance (Bartlett kernel)	0.001023

KPSS Test Equation
Dependent Variable: D(LNRPI)
Method: Least Squares
Date: 04/27/18 Time: 15:45
Sample (adjusted): 1956 2017
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.014301	0.005998	2.384403	0.0203
@TREND("1955")	-0.000142	0.000166	-0.856481	0.3951

R-squared	0.012078	Mean dependent var	0.009835
Adjusted R-squared	-0.004387	S.D. dependent var	0.023278
S.E. of regression	0.023329	Akaike info criterion	-4.646541
Sum squared resid	0.032654	Schwarz criterion	-4.577923
Log likelihood	146.0428	Hannan-Quinn criter.	-4.619600
F-statistic	0.733560	Durbin-Watson stat	0.828875
Prob(F-statistic)	0.395139		

Null Hypothesis: D(LNNER) is stationary
Exogenous: Constant, Linear Trend
Bandwidth: 0 (Newey-West automatic) using Bartlett kernel

		LM-Stat.
Kwiatkowski-Phillips-Schmidt-Shin test statistic		0.092300
Asymptotic critical values*:	1% level	0.216000
	5% level	0.146000
	10% level	0.119000

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

Residual variance (no correction)	0.006125
HAC corrected variance (Bartlett kernel)	0.006125

KPSS Test Equation
Dependent Variable: D(LNNER)
Method: Least Squares
Date: 04/27/18 Time: 15:43
Sample (adjusted): 1956 2017
Included observations: 62 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.007809	0.020454	0.381788	0.7040
@TREND("1955")	-5.37E-05	0.000565	-0.095060	0.9246

R-squared	0.000151	Mean dependent var	0.006118
Adjusted R-squared	-0.016514	S.D. dependent var	0.078906
S.E. of regression	0.079555	Akaike info criterion	-2.193011
Sum squared resid	0.379739	Schwarz criterion	-2.124394
Log likelihood	69.98335	Hannan-Quinn criter.	-2.166070
F-statistic	0.009036	Durbin-Watson stat	1.364955
Prob(F-statistic)	0.924584		

Ln(RPI) (1st difference)

$$H_0: \sigma_u^2 = 0$$
$$H_1: \sigma_u^2 \neq 0$$

Given that the critical values for $DF_{critical}$ statistic are:

1%: 0.216
5%: 0.146
10%: 0.119

Our LM statistic is 0.0943

Decision rule: reject H_0 if LM statistic> $DF_{5\%\ critical}$

Given that if LM statistic < $DF_{5\%\ critical}$, we fail to reject H_0 at the 5% level of significance and conclude that there is not enough evidence from the sample to suggest that the RPI is not stationary, ie the Ln (RPI) is stationary.

Ln(NER) (1st difference)

$$H_0: \sigma_u^2 = 0$$
$$H_1: \sigma_u^2 \neq 0$$

Given that the critical values for $DF_{critical}$ statistic are:

1%: 0.216
5%: 0.146
10%: 0.119

Our LM statistic is 0.0923

Decision rule: reject H_0 if LM statistic> $DF_{5\%\ critical}$

Given that if LM statistic < $DF_{5\%\ critical}$,we fail to reject H_0 at the 5% level of significance and conclude that there is evidence from the sample to suggest that the Ln(NER) is stationary.

When using the Augmented Dickey Fuller test, we find that we must reject the null hypothesis in both instances to prove stationarity. Conversely, when using the KPSS test, we find that we must accept the null hypothesis in both instances, to infer that the nominal exchange rate and the relative price index are stationary. It is important to note that this theory of inverse conclusions is only evident when testing for first differences. As the level output suggests, the KPSS test for Nominal exchange rate concluded that the time series was stationary without differencing. However, for consistency, both the ADF and KPSS test were re tested at 1st differences to confirm the inverse nature of conclusions, and that the time series were in fact stationary after differencing.

Part 1.5

The ADF outputs of level suggest that without differencing, both the Relative Price Index and Nominal e Exchange Rate data are not stationary. This is confirmed by the P value of RPI and NER being greater that 0.05. However, after 1st differencing we find that the time series data of both RPI and NER are stationary. This is confirmed by the respective P values of each data set being less than 0.05.

Conversely, the KPSS outputs suggest that without differencing, RPI is not stationary as its LM statistic is greater than the Dickey Fuller 5% critical values; Yet the NER is stationary as its LM statistic is less than the Dickey Fuller 5% critical values. However, to further confirm the presence of stationarity we have also tested KPSS at first difference and found that the LM statistic of both NER and RPI are less than the Dickey Fuller 5% critical values. Thus the KPSS test confirms that the time series of NER and RPI are stationary.

Thus, there is enough evidence to suggest that there is a high likelihood that the time series of the Relative Price Index and Nominal Exchange Rate are stationary after first differencing and thus follow a constant mean and constant variance.

Part 2.6

The Real Exchange Rate is defined as the ratio of the price level abroad and the domestic price level, where the foreign price is converted to the domestic price level, as a result of the nominal exchange rate. We solve for this mathematically using the below intuition:

$$q_{\frac{AUD}{USD}} = (E_{\frac{AUD}{USD}} * P_{USD})/(P_{AUD})$$
$$\therefore \log\left(q_{\frac{aud}{usd}}\right) = \log\left((E_{\frac{AUD}{USD}} * P_{USD})/(P_{AUD})\right)$$
$$= \log\left((E_{\frac{AUD}{USD}} * P_{USD})\right) - \log\left(p_{aud}\right)$$
$$= \log\left(E_{\frac{AUD}{USD}}\right) + \log\left(p_{usd}\right) - \log\left(p_{aud}\right)$$

Dependent Variable: RER
Method: Least Squares
Date: 04/29/18 Time: 15:45
Sample: 1955 2017
Included observations: 63

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	7.81E-13	1.09E-13	7.200999	0.0000
LNNER	1.000000	2.60E-14	3.84E+13	0.0000
LOGUS	1.000000	1.11E-13	9.04E+12	0.0000
LOGAS	-1.000000	8.78E-14	-1.14E+13	0.0000

R-squared	1.000000	Mean dependent var	0.324729
Adjusted R-squared	1.000000	S.D. dependent var	0.156050
S.E. of regression	3.06E-14	Sum squared resid	5.54E-26
F-statistic	5.36E+26	Durbin-Watson stat	0.296310
Prob(F-statistic)	0.000000		

Using the equation for the real exchange rate we are able to obtain the above regression. Through analysing the table, we notice that the R-squared value is greater than the Durbin-Watson Statistic (1>0.2963). This infers that we have a spurious regression and that using this model may lead to inaccurate hypothesis tests.

Through replicating the formula in Eviews, we have been able to produce the graphical representation of Real Exchange Rates. Through analysing the below graph, it is clear that the data appears to vary quite significantly over time. This would infer that there is a non-constant variance. The presence of a non- variance insinuates that the Real Exchange Rate data may not be stationary. To be sure of this, we will conduct an Augmented Dickey Fuller test.

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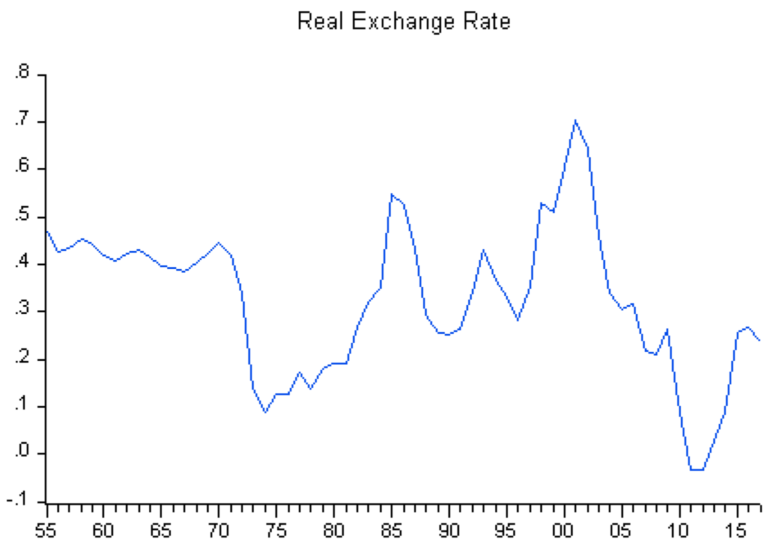


ADF(Level)

Null Hypothesis: RER has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.128992	0.1090
Test critical values:	1% level	-4.115684	
	5% level	-3.485218	
	10% level	-3.170793	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RER)
Method: Least Squares
Date: 04/27/18 Time: 20:36
Sample (adjusted): 1957 2017
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RER(-1)	-0.191236	0.061118	-3.128992	0.0028
D(RER(-1))	0.442722	0.118557	3.734262	0.0004
C	0.076275	0.030912	2.467531	0.0166
@TREND("1955")	-0.000500	0.000526	-0.951003	0.3456

R-squared	0.250162	Mean dependent var	-0.003119
Adjusted R-squared	0.210697	S.D. dependent var	0.077731
S.E. of regression	0.069058	Akaike info criterion	-2.444409
Sum squared resid	0.271835	Schwarz criterion	-2.305991
Log likelihood	78.55446	Hannan-Quinn criter.	-2.390161
F-statistic	6.338804	Durbin-Watson stat	1.933215
Prob(F-statistic)	0.000875		

From this output we will conduct a hypothesis test to determine if our data is stationary.

$$\Delta ln(RER_t) = \beta_0 + \beta_1 \ln(RER_{t-1}) + \delta_0 \Delta \ln(RER_{t-1}) + \beta_2 t + \epsilon_t$$

$$\Delta ln(\widehat{RER}_t) = 0.0763 - 0.1912 \ln(RER_{t-1}) + 0.4427 \Delta \ln(RER_{t-1}) - 0.0005t$$

(se) (0.0309) (0.0611) (0.1186) (0.0005)

$$H_0: \delta_0 = 0 \ (rer\ is\ not\ stationary)$$
$$H_1: \delta_0 < 0 \ (rer\ is\ stationary)$$

P value=0.1090

Decision rule: reject H_0 if $P\ value < 0.05$

Given that our P value> 0.05 we fail to reject H_0 at the 5% level of significance and conclude that there is not enough evidence from the sample to suggest that the real exchange rate is stationary at level I(0). Thus we will now test if our real exchange rate data becomes stationary after first differencing.

Null Hypothesis: D(RER) has a unit root
Exogenous: Constant, Linear Trend
Lag Length: 0 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-5.299109	0.0003
Test critical values:	1% level	-4.115684	
	5% level	-3.485218	
	10% level	-3.170793	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RER,2)
Method: Least Squares
Date: 04/27/18 Time: 20:37
Sample (adjusted): 1957 2017
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RER(-1))	-0.651883	0.123017	-5.299109	0.0000
C	-0.001532	0.019705	-0.077724	0.9383
@TREND("1955")	-1.37E-05	0.000539	-0.025332	0.9799

R-squared	0.326486	Mean dependent var	0.000186
Adjusted R-squared	0.303261	S.D. dependent var	0.088782
S.E. of regression	0.074107	Akaike info criterion	-2.318685
Sum squared resid	0.318527	Schwarz criterion	-2.214871
Log likelihood	73.71988	Hannan-Quinn criter.	-2.277999
F-statistic	14.05775	Durbin-Watson stat	1.852090
Prob(F-statistic)	0.000011		

$$\Delta^2 \ln(RER_t) = \beta_0 + \delta_0 \Delta^2 \ln(RER_{t-1}) + \beta_1 t + \epsilon_t$$
$$\Delta^2 \widehat{\ln(RER_t)} = -0.0015 - 0.6519\Delta^2 \ln(RER_{t-1}) - 1.37E^{-05}t$$

(se) (0.0197) (0.1230) (0.0005)

$$H_0: \delta_0 = 0 \ (rer\ is\ not\ stationary)$$
$$H_1: \delta_0 < 0 \ (rer\ is\ stationary)$$

P value=0.0003

Decision rule: reject H_0 if $P\ value < 0.05$

Given that our P value< 0.05 we reject H_0 at the 5% level of significance and conclude that there is enough evidence to suggest that the real exchange rate is stationary after first differencing at I(1).

Through the discovery that, after differencing, the real exchange rate is stationary, we can now assume that any random disturbances do not have permanent effect on the real exchange in the long run. That is, in the long run the real exchange rate will return to an average value over time. Consequently, the implication for Relative Purchasing Power Parity (RPPP) is that if the real exchange rate is integrated of order 1 it exhibits random walk behaviour and e_t and p_t-p^*_t is not co-integrated. This implies RPPP will not hold in the long run.

Part 2.7

Theory suggests that testing RPPP requires the following regression model:

$$e_t = \beta_0 + \beta_1 p_t - \beta_2 p_t^* + \epsilon_t$$

Where the lowercase letters, e_t,p_t and p^*_t denote the natural log of the nominal exchange rate, domestic price level (Australian CPI) and foreign price level retrospectively. From here, we make the further simplifying assumption that $\beta_1 = \beta_2$ to denote the proportionality. Thus the regression model becomes:

$$e_t = \beta_0 + \beta_1 p_t - \beta_1 p_t^* + \epsilon_t$$
$$e_t = \beta_0 + \beta_1 (p_t - p_t^*) + \epsilon_t$$

Through running this regression in Eviews, we are able to obtain the following output:

Dependent Variable: LNNER
Method: Least Squares
Date: 05/01/18 Time: 16:13
Sample: 1955 2017
Included observations: 63

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.289823	0.027705	10.46097	0.0000
LNA-LNU	0.849198	0.085719	9.906774	0.0000

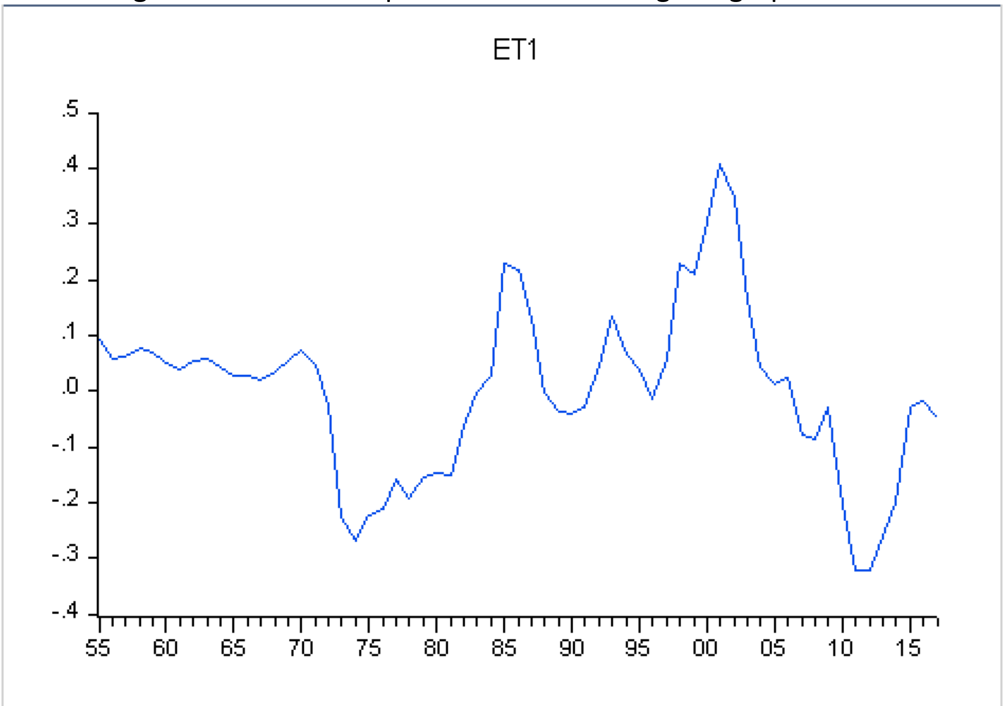
R-squared	0.616700	Mean dependent var	0.093259
Adjusted R-squared	0.610416	S.D. dependent var	0.245893
S.E. of regression	0.153478	Akaike info criterion	-0.879287
Sum squared resid	1.436887	Schwarz criterion	-0.811251
Log likelihood	29.69753	Hannan-Quinn criter.	-0.852528
F-statistic	98.14418	Durbin-Watson stat	0.252177
Prob(F-statistic)	0.000000		

$$\widehat{e_t} = 0.2898 + 0.8492(p_t - p_t^*) + \widehat{\epsilon_t}$$

(se) (0.0277) (0.085719)

The regression output suggests that the model may be spurious as the R^2>DW statistic (0.6167>0.2522). Consequently we must now test for co-integration of these variables. To do this the estimated error of residuals must be obtained through Eviews.

After doing so we are able to produce the following the graph of residuals:



Through analysis of the above graph we see that over time the graph appears to oscillate around a constant mean of one, whilst the variance does not appear to be constant. This suggests that the residuals may be non-stationary at level (I(0)). However, to test our speculations, we will now conduct an ADF test to conclude if the residuals are stationary.

Null Hypothesis: ET1 has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.048962	0.0028
Test critical values:	1% level	-2.603423	
	5% level	-1.946253	
	10% level	-1.613346	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ET1)
Method: Least Squares
Date: 05/03/18 Time: 11:12
Sample (adjusted): 1957 2017
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ET1(-1)	-0.180077	0.059062	-3.048962	0.0034
D(ET1(-1))	0.428873	0.117319	3.655607	0.0005

R-squared	0.236146	Mean dependent var	-0.001711
Adjusted R-squared	0.223199	S.D. dependent var	0.077568
S.E. of regression	0.068366	Akaike info criterion	-2.495649
Sum squared resid	0.275760	Schwarz criterion	-2.426440
Log likelihood	78.11729	Hannan-Quinn criter.	-2.468525
Durbin-Watson stat	1.930998		

$$\Delta e_t = \beta_0 e_{t-1} + \delta_0 \Delta e_{t-1}$$
$$\widehat{\Delta e_t} = -0.1801 + 0.4389 \Delta e_{t-1}$$
(se) (0.0591) (0.1173)

H_0: *the series are not cointegrated* $\rightarrow$ *residuals are nonstationary*
H_1: *The series are cointegrated* $\rightarrow$ *residuals are stationary*

τ *statistic* $= -3.048962$
5% Mackinnon critical value(bivariate) =-3.46

Decision rule: reject H_0 if τ *statistic* $<$ 5% Mackinnon critical value

Given that -3.0489>-3.46, we fail to reject H_0 at 5% level of significance and conclude that the variables, e_t,p_t and p^*_t do not form some linear relationship at I(0) and are non-stationary. Thus we can conclude that the variables are not co-integrated, even though it was found that stationarity was present after 1st differencing (I(1)). This further confirms our earlier findings that there are no unique long run combinations of variables that will allow RPPP to hold in the long run.

Part 2.8

In order test all variables for co-integration, we will relax the assumptions applied to the previous formula in Part 2.7. That is now $\beta_1 \neq \beta_2$. We still denote natural logs through lower case letters.

$$e_t = \beta_0 + \beta_1 p_t - \beta_2 p_t^* + \epsilon_t$$

Through running this regression in Eviews, we are able to obtain the following output:

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Dependent Variable: LNNER
Method: Least Squares
Date: 05/01/18 Time: 18:35
Sample: 1955 2017
Included observations: 63

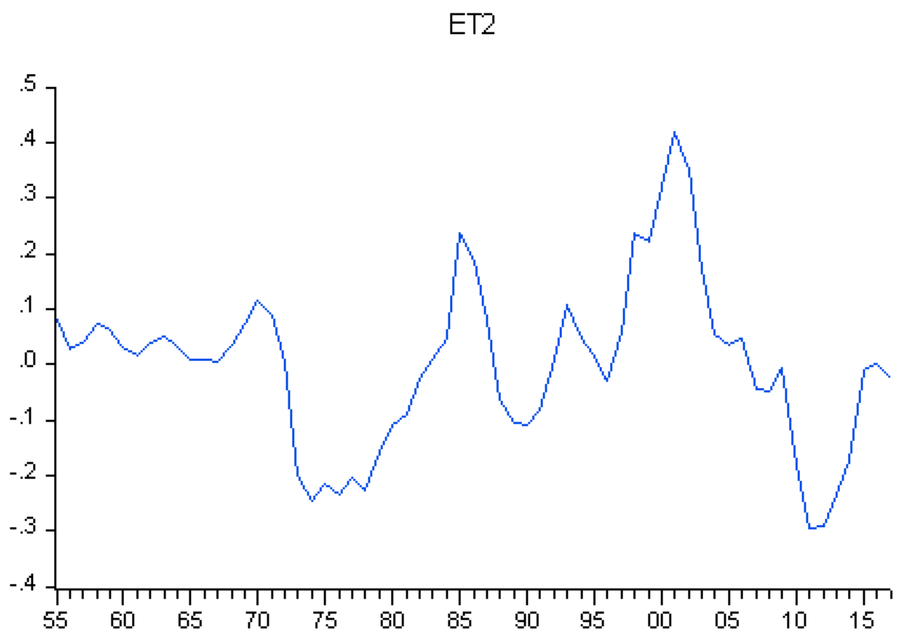
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	1.070146	0.520094	2.057601	0.0440
LNA	1.427941	0.394436	3.620213	0.0006
LNU	-1.601733	0.508011	-3.152952	0.0025

R-squared	0.630597	Mean dependent var	0.093259
Adjusted R-squared	0.618284	S.D. dependent var	0.245893
S.E. of regression	0.151920	Akaike info criterion	-0.884472
Sum squared resid	1.384788	Schwarz criterion	-0.782418
Log likelihood	30.86088	Hannan-Quinn criter.	-0.844334
F-statistic	51.21222	Durbin-Watson stat	0.272434
Prob(F-statistic)	0.000000		

$$\widehat{e_t} = 1.0701 + 1.4279 p_t - 1.6017 p_t^* + \widehat{\epsilon_t}$$

(se) (0.5201) (0.3944) (0.5080)

The regression output suggests that R^2>DW statistic (0.6306>0.2724). This implies that the model may be spurious. As it suspects this may be a problem, we will test for co-integration of these variables by first obtaining the estimated error of residuals. Through Eviews we simply produce residuals using proc then make residual series.



Through analysis of the above graph we see again that over time the graph appears to oscillate around a constant mean of one but the variance does not appear to be constant. This would further suggest that the residuals may be non-stationary at level (I(0)). Again, to test our speculations, we will now conduct an ADF test conclude if the residuals are stationary.

Null Hypothesis: ET2 has a unit root
Exogenous: None
Lag Length: 1 (Automatic - based on SIC, maxlag=10)

		t-Statistic	Prob.*
Augmented Dickey-Fuller test statistic		-3.326976	0.0012
Test critical values:	1% level	-2.603423	
	5% level	-1.946253	
	10% level	-1.613346	

*MacKinnon (1996) one-sided p-values.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(ET2)
Method: Least Squares
Date: 05/03/18 Time: 11:32
Sample (adjusted): 1957 2017
Included observations: 61 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ET2(-1)	-0.198920	0.059790	-3.326976	0.0015
D(ET2(-1))	0.469214	0.114337	4.103785	0.0001

R-squared	0.274859	Mean dependent var	-0.000850
Adjusted R-squared	0.262569	S.D. dependent var	0.078976
S.E. of regression	0.067820	Akaike info criterion	-2.511694
Sum squared resid	0.271370	Schwarz criterion	-2.442485
Log likelihood	78.60667	Hannan-Quinn criter.	-2.484571
Durbin-Watson stat	1.909041		

$$\Delta e_t = \beta_0 e_{t-1} + \delta_0 \Delta e_{t-1}$$
$$\Delta \widehat{e_t} = -0.1989 e_{t-1} + 0.4692 \Delta e_{t-1}$$

(se) (0.0598) (0.1143)

H_0: $the\ series\ are\ not\ cointegrated \rightarrow residuals\ are\ nonstationary$
H_1: $The\ series\ are\ cointegrated \rightarrow residuals\ are\ stationary$

$\tau\ statistic = -3.326976$
5% MacKinnon Critical value(multivariate)=-3.92
Decision rule: reject H_0 if $\tau\ statistic < 5\%\ MacKinnon\ critical\ value$

Given that the -3.326976 >-3.92, we fail to reject H_0 at 5% level of significant and conclude that residual of the error is non stationary and thus the time series is not co-integrated. This is in line with our earlier result that suggested that the time series was not co-integrated. However, it is important to note that earlier we were testing the co-integration within RPPP, but now with the assumption relaxed we are able to test for co-integration within PPP. Thus the result that there is no linear combination of e_t, p_t, p_t^* at I(0), despite that the overall time series being stationary after I(1) further confirms the discrepancy between economic theory of PPP and what occurs in reality. In that, PPP will never truly hold or equal 1 in the long run, due to costs such as transportation and taxes that are not included in the model.

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Part 2.9

Purchasing Power Parity (PPP) suggests that the exchange rate between two currencies is equal to the ratio of their respective purchasing power. If PPP holds, ie PPP=1, we see that the two currencies have the same retrospective purchasing power. More importantly, if PPP holds in the long run, we assume that prices everywhere are equal and that there are no arbitrage opportunities available to profit. To test the theory of PPP, we first applied Augmented Dickey Fuller testing to the real exchange rate.

We applied the ADF test to determine if the real exchange rate was a stationary time series. This is extremely important in relation to PPP economic theory because if the real exchange rate between two countries is stationary, it infers that the data will have a constant average. This would imply that in the long run the real exchange rate would converge to a constant price (1), and any arbitrage opportunities (i.e. shocks/disparity in pricing) would dissipate over time and PPP will hold. Through the ADF testing, it was found that stationarity does not exist at level (I(0)) but does exist after differencing at I(1). In other words, using a differenced formula for the real exchange rate allows us to use hypothesis testing to investigate how the exchange rate may change as a result of fluctuations in prices between a domestic and foreign currency. Moreover, the presence of stationarity after 1st differencing suggests that the real exchange rate will have a constant average in the long run, which is consistent with the theory for PPP that the exchange rate will be equal (1:1) between two currencies in the long run. Furthermore, proving that stationarity doesn't exist at level (I(0)) infers that over the same time period there is no constant average, which implies that there could be fluctuations in prices and exchanges in the short run; and therefore RPPP may exist.

After applying the assumption that $\beta 1 = \beta 2$ to the PPP formula to create the RPPP regression, we discovered that the residuals of RPPP are not stationary at I(0). This implies that cointegration does not exist as it requires the time series to be stationary at I(1) and there is evidence of some linear combination of variables at I(0). The presence of Non-stationary timeseries I(0) implies that there is no linear combination between e_t, p_t, p_t^* and that no unique long run equation exists. This further confirms that RPPP does not hold in the long run and depends on the time period when calculated.

Similarly, after relaxing the assumption that $\beta 1=\beta 2$ (ie $\beta 1$ and $\beta 2$ are now different) we re-ran an ADF test against the full PPP regression and found that the residuals of PPP were not stationary at I(0). This implies that there is no linear relationship between e_t, p_t, p_t^* and that there is no unique long run equation. This confirms that PPP does not hold in the long run, despite economic theory suggesting that PPP will hold.

Through testing we have found that there is significant evidence to support the theory that PPP will not hold in the long run. This is despite the fact that the real exchange rate is stationary after first differencing (I(1)), suggesting that the real exchange rate is constant over time. Further, it was found that when testing for cointegration, there was no linear relationship (using the full PPP regression) between e_t, p_t, p_t^* at level (I(0)). This infers that the variables e_t, p_t, p_t^* are not cointegrated and that there is no unique long run relationship between the variables and thus PPP will not hold in the long run.

Despite the findings, testing for PPP using Augmented Dickey Fuller tests do not conclusively prove the existence of PPP in reality. The tests themselves, and simplified regression models of PPP fail to take into the hidden costs associated with prices around the world. Such hidden costs include taxes, tariffs and transportation costs. The application of taxes to prices causes disparity in like for like goods and services around the world, meaning that prices will never be level, and thus the exchange rate will never equal to one. Further transport costs associated with specific goods differ depending on the location of where the good is produced, and where the final good is sold. For example, the price of Columbian coffee beans in Columbia is less than the price of Columbian coffee beans in Australia. Thus there is going to be obvious price disparity in the prices of two goods. It is due to this disparity caused by taxes and transports cost that result in PPP not holding in the long run. Lastly it is important to consider the Balassa-Samuelson hypothesis for pricing disparity. The hypothesis suggests that long run deviations from PPP are a result of rich countries tending to have higher price levels than poorer countries, due to rich countries being relatively more productive in the traded goods sector, the existence of higher wages and thus a higher capital-labour ratio. Thus for future research to be effective, a PPP regression model would need to include variables for transport costs and taxes, tariffs and all endogenous variables that relate to changes in prices levels between countries. However, it may be quite difficult to include and account for all relevant variables in a model, and could potentially lead to over specification. This would mean that a model may be good at explaining historical real exchange rate data, but will not be effective in forecasting future exchange rates and ultimately determining if PPP will hold in the long run.