PURCHASING POWER PARITY THEORY AND ITS VALIDITY IN PACIFIC ISLAND COUNTRIES

T. K. Jayaraman* and Chee-Koeng Choong**

Abstract. . Among the 14 Pacific island countries (PICs), six have independent currencies, of which five, namely Fiji, Samoa, Solomon Islands, Tonga and Vanuatu, have fixed exchange rate regimes, while the sixth, namely Papua New Guinea, has a flexible exchange rate regime. The other eight are dollarized economies, having adopted one of the currencies of Australia, New Zealand and the United States. This paper investigates whether the purchasing parity power theory holds with regard to five countries under fixed exchange rate regimes. Our findings show that long-run PPP hypothesis holds for all five PICs.

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Introduction

The purchasing power parity (PPP) theory is an elegant proposition in economics. It is based on the law of one price. The law states that under the assumptions of absence of trade barriers as well as absence of transportation costs, or at low transportation costs, prices in two countries of goods of similar quality when expressed in terms of the same currency, should be identical. The PPP theory is thus enunciated from the aforesaid law of one price as follows: exchange rates between any two countries will adjust over time to reflect changes in their respective price level (Mishkin 2012). Undoubtedly, the PPP theory has enchanted empirical economists over a long time.

There have been several empirical studies on the validity of PPP theory which are available with respect of both developed and developing countries. They relate to different times. Some studies are on the same set of countries but were for different sets of periods as well. The findings are nearly universal: the PPP theory has little predictive power in the short run, despite the fact that theory provides some guidance to movements in exchange rates over a period of time. But many studies indicate that the PPP theory holds in the long run. Thus, policy makers are now aware by the findings of these empirical studies that in the long-run, if a given country's price level has been increasing to a relatively higher level than that of another country's price level, its currency would tend to depreciate.

There are no studies on the validity or otherwise of PPP theory with regard to small island states in the Pacific region. Amongst the 14 Pacific island countries (PICs), six of them have independent currencies. The other nine are dollarized economies having adopted one of the currencies of three metropolitan powers, namely Australia, New Zealand and the United States. The six PICs with independent currencies are Fiji, Papua New Guinea (PNG), Samoa, Solomon Islands, Tonga and Vanuatu. Out of the six, PNG has a floating exchange rate regime since 1994. The other five PICs have fixed exchange rate regimes. According to the IMF official classification, reported in the Annual Report on Exchange Arrangements and Exchange Restrictions, the currencies of Fiji, Samoa, Tonga and Vanuatu have been pegged to a basket of currencies for the past two decades or more, whereas the exchange rate of Solomon Islands which was pegged to United States (US) dollar currency, has since September 2012, been pegged to a basket of trading partner currencies with US dollar having the largest proportion.

This paper, which will be an addition to the growing literature on PPP theory, seeks to test the validity of this theory with regard to the exchange rates of five PICs, namely Fiji, Samoa, Solomon Islands, Tonga and Vanuatu by undertaking an empirical study over a period of three decades. The paper is organised along the following lines. The second section presents a brief review of the findings of notable empirical studies on the validity of the PPP hypothesis, whereas the third section introduces the methodology adopted for the five PICs, with econometric details presented in the Technical Appendix. The fourth presents the results. The concluding section contains some policy implications.

A Brief Review of Theoretical and Empirical Studies

Observing that PPP theory is the cornerstone of the monetary models of exchange rate determination, Dornbusch (1976), Musa (1982) and Anorou et al., (2005) note that deviations from PPP occur in the short-run. Thus, the finding is that the theory is valid only in the long run. The short-run deviations are evidenced in studies notably by Dornbusch (1980) and Frenkel (1978). However, all studies focusing on the long run validity of PPP theory did not come out with unanimous results. While for example, Abuaf and Jorian (1990) and Meef and Rogoff (1988), found evidence of PPP theory holding in the long run, Cooper (1994) and Ahking (1997) obtained evidence to the contrary.

Anorou et al., (2005) in their succinct literature survey note that the turning point in the investigation of the PPP theory came about with the finding that nominal exchange rate has unit roots, indicating that nominal exchange rate follows a random walk and its impact is not mean reverting. Considering that changes in nominal exchange rate are likely to be permanent, the long run PPP theory could be confirmed only if the existence of unit roots are rejected (Adler and Lehman 1983; Manzur and Ariff 1995).

Various authors used different tests. While Mansur and Ariff (1995) and Whitt (1992) used Sim tests, Ahking (1997) used Bayesian unit root approach. Huang and Yang (1996) employed the Engle and Granger (1987) two-step approach and Johansen (1988) used a maximum likelihood procedure as well as Monte-Carlo simulations and obtained different results. Lee (1999) used a generalised error correction model for 13 Asian countries.

As regards different exchange rate regimes, studies by Derodan, et al., (1999) found that in the long run PPP is valid under a floating exchange rate regime. In their study of exchange rates of 11 developing countries, Anorou et al., (2005) conducted

unit root tests using both Augmented Dickey Fuller tests and Phillipe-Perron procedures to determine the order for integration. Further, the authors adopted a dynamic error correction model (DECM) to examine the existence of long run PPP because of the special property that DECM relaxes the restrictions implicit in the traditional unit roots procedures and treats both nominal exchange rate and price ratio as endogenous variables.

Data and Modelling Methodology

The data utilised in the present study are quarterly figures (summarised in Tables 1 and 2), covering a period of three decades: 1980Q1-2011Q4. The nominal exchange rates are units of domestic currency per unit of the US dollar. The price level data of the five PICs are consumer price indices, while the foreign price level is the consumer price index of the US. All data are drawn from the *International Financial Statistics*, an International Monetary Fund publication (IMF 2012).

Modelling PPP Relationship

The PPP theory proposes that the exchange rate relies on relative price levels, as follows:

$$r_t = \beta 0 + \beta 1\, p_t + \beta 1 p_t^* \qquad (1)$$

where r_t is the log of the nominal exchange rate (units of domestic currency per unit of the US dollar), p_t and p_t^* are the logs of domestic and foreign prices, respectively. Equation (1) suggests that weak PPP relationship exists if there is evidence of co-integration among r_t , p_t and p_t^* . If we impose the symmetry condition $\beta 1 = - \beta 2$ on prices, then this restriction shows a new PPP relationship.

$$rt = \beta_0 + \beta_1\ (p_t - p_t^*) \qquad (2)$$

Since we impose the symmetry condition in Equation (2), this equation can only have a single co-integrating vector. In our further testing, if we impose the proportionality condition on the relative price coefficient in Equation (2), then we can examine the existence of strong PPP relationship in PICs. In this study, we investigate the validity of both symmetry and joint symmetry and proportionality assumptions in PICs.

Table 1
Pacific Island Countries: Nominal Exchange Rates

Year	F$/	Tala/	Sol$/	Ton$/	Vat/
1981-1990*	1.25	1.89	1.64	1.23	104.21
1991-2000*	1.63	2.67	3.76	1.40	119.70
2001-2005*	1.96	3.06	6.91	2.08	125.55
2006	1.73	2.78	7.61	2.03	110.64
2007	1.61	2.62	7.65	1.97	102.44
2008	1.59	2.64	7.75	1.94	101.33
2009	1.96	2.73	8.06	2.03	106.74
2010	1.92	2.48	8.06	1.91	96.91
2011	1.79	2.32	7.64	1.73	92.61

*average

Table 2

Pacific Island Countries: Annual change in price level percent

Year	Fiji	Samoa	Sol. Is.	Tonga	Vanuatu
1981-1990*	7.3	14.7	16.9	12.75	7.26
1991-2000*	3.2	4.1	13.76	3.5	2.62
2001-2005*	2.1	5.6	7.6	9.62	1.56
2006	2.5	3.7	11.22	6.44	2.04
2007	4.8	5.6	7.6	5.89	3.96
2008	7.7	11.5	17.3	10.44	4.83
2009	3.7	6.2	7.1	1.4	4.25
2010	5.5	1.1	1.0	3.54	2.8

* average

The formal methodology is presented in the Technical Appendix. Since we use panel data for analysis, tests for panel co-integration are employed. Detailed econometric procedures and the results obtained are also documented in the Technical Appendix.

Results

The validity of PPP theory is examined with regard to the exchange rates of five Pacific Island countries, namely Fiji, Samoa, Solomon Islands, Tonga and Vanuatu for the period of 1980Q1-2011Q4. We find support for the PPP hypothesis in all these PICs by using different econometric techniques such as panel unit root tests, as well as Pedroni's and Johansen's panel co-integration tests.

The requirement for establishing the validity of strong PPP hypothesis by the panel analysis is the existence of two restrictive conditions relating to joint symmetry and proportionality. Although our results suggest that domestic and foreign prices are crucial determinants of the exchange rate in the long run in all PICs, the estimates do not necessarily comply with the restrictive conditions. By employing Johansen multivariate co-integration test to each of the five PICs, however, we find that the results confirm the existence of long run validity of PPP.

Conclusions and Implications

The results of this study suggest that policy makers in the governments of PICs should continue to be guided by the PPP theory, implying that rising price levels relative to those of other countries would eventually lead to depreciation of currencies. The effects of depreciation are serious. Depreciation would raise the costs of critical imports of mass consumption and intermediate and capital goods, which will not only push up the domestic price level but also reduce the competiveness of PICs' limited range of exports.

In the absence of a wide range of exportable products, small island economies which depend on very limited range of exports such as copra, fish and tourism, against the huge import needs of critical nature ranging from food and fuel to machinery and manufactured goods, will face balance of payments problems.
The governments of the countries considered in this study face challenging tasks, in attempting to control increases in domestic price levels by monitoring inflation rates and enhancing export competitiveness. One sure way open to them is to keep fiscal deficits under control and avoid their monetization. Prudent fiscal and monetary policies alone will contribute to stability and growth.

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TECHNICAL APPENDIX

Panel Co-integration Tests

Assuming that are integrated of order one, I(1) and we consider the following time series model:

$$y_t = \alpha + \beta x_t^{'} + u_t \,, \qquad \text{(A 1)}$$

where $x_t^{'}$ is a vector of I(1) variables and the co-integrating vector is $(1, -\beta^{'})$.

Equation (A1) can be estimated by applying single equation and or system techniques. In this study, the equation was estimated by using single equation technique developed by Pedroni (1997, 1999, 2000, 2001). Pedroni's panel data framework is derived under the null hypothesis that there is no co-integration. Based on this framework, Pedroni develops seven panel co-integration statistics, namely four statistics are based on within-dimension technique and three are based on between-dimension technique. According to Pedroni (1997), the distribution of these statistics is a normal distribution given by

$$k = \frac{k_{N,T} - u\sqrt{N}}{\sqrt{v}} \Rightarrow N(0,1)$$

where $k_{N,T}$ is the panel co-integration statistic and and are the moments of the Brownian function (i.e. expected mean and variance) that are computed in Pedroni (1999).

Panel fully modified OLS (FMOLS) estimates

For the purpose of examining the validity of PPP hypothesis, this study adopted the panel group mean Fully Modified OLS following the work by Pedroni (2000). The FMOLS procedure can accommodate the heterogeneity problem that is normally present in the transitional serial correlation dynamics and in the long run co-integrating relationships.

We consider the following panel data models:

$$y_{it} = \alpha_i + \beta_i x_{it}^{'} + u_{it} \qquad \text{(A 2)}$$

$$x_{it} = x_{i,t-1}^{'} + e_{it} \qquad \text{(A 3)}$$

Where

$i = 1, 2, \ldots, N$ countries over the period of $i = 1, 2, \ldots, M$. In addition, $z_{it} = (y_{it}, x_{it})^{'} \sim I(1)$ and $\omega_{it} = (u_{it}, e_{it})^{'} \sim I(0)$ with covariance matrix of $\Omega_i = \Omega_i^0 + \Gamma_i + \Gamma_i^{'}$ where Ω_i^0 is the contemporaneous covariance, Γ_i is the weighted sum of autocovariances while $\Omega_i = L_i L_i^{'}$ in which L_i is the lower triangular decomposition of Ω_i. It is assumed that $y = r$ while $x = [p, p^*]$ of Equation (1). The panel fully modified OLS (FMOLS) estimator for coefficient β is given as

$$\beta_{NT}^{*} = N^{-1} \sum_{i=1}^{N} \left(\sum_{t=1}^{T} \left(x_{it} - \bar{x}_i \right)^2 \right)^{-1} \left(\sum_{t=1}^{T} \left(x_{it} - \bar{x}_i \right) y_{it}^{*} - T\hat{\gamma}_i \right)$$

where

$y_{it}^{*} = (y_{it} - \bar{y}_i) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta x_{it}$ and $\hat{\gamma}_i = \hat{\Gamma}_{21i} + \hat{\Omega}_{21i}^0 - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \left(\hat{\Gamma}_{22i} + \hat{\Omega}_{22i}^0 \right)$. The associated t-statistics for the estimator can be

estimated as $t^{*}_{\hat{\beta}_{IM}} = N^{-1/2}\sum_{i=1}^{N} t^{*}_{\hat{\beta}_{IM,i}}$ where $t^{*}_{\hat{\beta}_{IM}} = \left(\hat{\beta}^{*}_{IM,i} - \beta_{0}\right)\left(\hat{\Omega}^{-1}_{11,i}\sum_{t=1}^{T}(x_t - \bar{x}_i)^2\right)^{1/2}$

After obtaining the estimates, we normalized the equation with respect to y_t as we intend to focus only on a single co-integrating vector, that is $\beta^{'}$ is unique.

In general, a necessary condition for PPP hypothesis to hold is that the relative price is stationary; otherwise, deviations or disequilibrium from PPP would be permanent. Hence, we first employ four types of panel unit root tests, namely proposed by Levin et al., (2002), Im et al., (1997) and Maddala and Wu (1999). These panel unit root tests are superior than the univariate time series tests (ADF and PP tests).

The test proposed by Levin et al., Lin and Chu (2002) is under the assumption of homogeneity across individuals. On the other hand, the tests proposed by Im et al., (1997) and Maddala and Wu (1999) are well-known with a good, small sample properties; and they also allow for individual specific effects and dynamic heterogeneity across groups to examine price differences between countries (Esaka, 2003: 234).

Non-stationarity property

As shown in Table A1, we could reject the unit root null of exchange rate, domestic price (p) and foreign price (p*) at first difference. The non-stationarity property of exchange rates is not surprising because a time trend would not be consistent with long-term PPP (Papell, 1997). Thus, it is suggested that the exchange rate, domestic and foreign prices are I(1) stochastic processes for the whole panel of PICs. As the exchange rate is stationary at I(1), this indicates that exchange rate exhibits a high degree of persistence and does not support the mean reversion hypothesis. This finding is in line with few studies such as Papell (1997), O'Connell (1998), Cerrato and Sarantis (2002) and Coakley, et al., (2005).

Pedroni's (2004) Co-integration Tests

On the basis of the panel unit root results, we proceed to examine the validity of PPP hypothesis in these five PICs by using Pedroni's (2004) co-integration tests.

The results are shown in Table A2. The null hypothesis of no co-integration is rejected by four within-dimension panel co-integration statistics and by three between-dimension panel co-integration statistics provided by Pedroni (1999). Hence, we conclude that exchange rate, and domestic and foreign prices are co-integrated.

Table A1

Panel Unit Root Tests

Panel Unit root tests	Nominal Exchange Rates		Domestic Price, p		Foreign Price, p^*	
	Level	1st Difference	Level	1st Difference	Level	1st Difference
	Null: Unit root (assumes common unit root process)					
Levin, Lin & Chu t*	-0.039 [0.4845}	-20.113*** [0.0000]	-0.713 [0.2377]	-7.625*** [0.0000]	2.585 [0.9951]	-6.936*** [0.0000]
	Null: Unit root (assumes individual unit root process)					
Im, Pesaran and Shin W-stat	1.432 [0.9241]	-18.542*** [0.0000]	0.736 [0.7693]	-4.327*** [0.0000]	1.545 [0.9389]	-9.736*** [0.0000]
ADF - Fisher Chi-square	6.002 [0.815]	260.159*** [0.0000]	12.847 [0.2323]	45.206*** [0.0000]	2.174 [0.9948]	113.064*** [0.0000]
PP - Fisher Chi-square	3.203 [0.9762]	259.932*** [0.0000]	7.625 [0.8169]	33.826*** [0.0002]	2.103 [0.9964]	133.754*** [0.0000]

Notes:
Under the null hypothesis, the IPS test statistic is asymptotically distributed as a standard normal distribution. The (common) lag length is chosen on the basis of the AIC. The numbers in parentheses denote lag length and those in brackets are P-values. The P-values are estimated from the one-tail test of the standardized normal distribution.
Under the null hypothesis, the probabilities for Fisher tests are computed using an asymptotic Chi-square distribution. The lag length is chosen on the basis of the AIC and is set equal to the value chosen by the individual ADF regressions. Hence, we cannot present the common lag length, because the lag length varies country by country (regression by regression).
*** Significant at the 1 percent level.

Table A2

Pedroni Residual Co-integration Test Results

Test Statistics	
Panel co-integration statistics (within-dimension)[a]	
Panel p-statistic	2.0020** [0.0226]
Panel PP type p-statistic	-3.2718*** [0.0005]
Panel PP type t-statistic	-3.9439*** [0.0000]
Panel ADF type t-statistic	-4.1937*** [0.0000]
Group mean panel co-integration statistics (between-dimension)[b]	
Group PP type p-statistic	-1.5659* [0.0587]
Group PP type t-statistic	-2.9992*** [0.0014]
Group ADF type t-statistic	-3.3239*** [0.0004]

Notes:
The number of lag truncations used in the calculation of the seven Pedroni statistics is 3. The numbers in brackets are P-values.
a The within-dimension tests take into account common time factors and allow for heterogeneity across countries.
b The between-dimension tests are the group mean co-integration tests, which allow for heterogeneity of parameters across countries.
Asterisks *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively.

The validity of PPP hypothesis is further confirmed by the Johansen Fisher panel co-integration test, as shown in Table A3.

Table A3

Johansen Fisher Panel Co-integration Test Results (Lag 2)

Hypothesized No. of CE(s)	Unrestriced Co-integration Rank Test Fisher Statistics			
	Trace Test	Probability*	Maximum Eigenvalue Test	Probability*
r=0	23.57***	0.0088	21.35**	0.0188
r=1	13.18	0.1301	11.29	0.3351
r=2	5.28	0.7895	5.28	0.7895

Notes:
* Probabilities are computed using asymptotic Chi-square distribution.
Asterisks ** and *** indicate significance at the 5 and 1 percent levels, respectively.

The long run estimates for each of the five PICs and for the panel of PICs, based on Pedroni's FMOLS estimator, are shown in Table A4. For all five PICs, it is found that the intercept appears to be positive and significant at 5% significance level. Looking at the domestic prices, the coefficients are significant in all countries with an expected positive sign. In contrast, the coefficients on the foreign price are negative as expected and they are also significant in all countries at least at 5% level. Therefore, the findings from both the Pedroni and Johansen Fisher panel co-integration tests supports the presence of a long-run relationship among the exchange rate, domestic and foreign prices for five PICs.

Table A4

Pedroni's Fully Modified OLS Estimates

	Intercept	Domestic Price, p	Foreign Price, p^*
	(β_0)	(β_1)	(β_2)
Fiji	2.0104**	1.2253***	-1.0949***
	(2.2511)	(2.8919)	(-14.855)
Samoa	3.0057***	1.3710***	-2.1804***
	(2.8428)	(3.4724)	(-5.0629)
Solomon Islands	2.4291***	0.8390***	-2.1051**
	(5.3163)	(5.3561)	(-1.9768)
Tonga	4.1544***	1.1574***	-0.9456***
	(3.9434)	(3.6051)	(-3.7447)
Vanuatu	6.0711***	1.3711**	-0.9162***
	(3.5947)	(1.9744)	(-6.0812)

Notes:
The number of lag truncations used in the calculation of the seven Pedroni statistics is 4. Numbers in parentheses below regression coefficients are t-values.
Asterisks ** and *** indicate significance at the 5 and 1 percent levels, respectively.

The results of both Pedroni and Johansen Fisher panel co-integration tests favour the weak PPP hypothesis, in contrast with the findings for the PPP reported by some panel unit root tests of the exchange rate. Therefore, we suspect these contrasting findings might be due to joint symmetry and proportionality restrictions imposed on panel unit root tests of the exchange rate (Frankel and Rose, 1996). To examine the robustness and validity of results, we use the Johansen multivariate co-integration test to individual PICs.

Johansen multivariate co-integration tests for each PIC

The trace and maximum eigenvalue test statistics are exhibited in Table A5.

Table A5

Johansen Multivariate Co-integration Test

Country	Trace Statistic	Maximum Eigenvalue Statistic	Rank, r_i
Fiji			
r=0	53.762***	32.198***	1
r=1	21.563	14.130	
r=2	7.433	7.433	
Samoa			
r=0	39.0618***	26.9289***	1
r=1	12.1328	11.5666	
r=2	0.5662	0.5662	
Solomon Islands			
r=0	34.7379**	21.4444**	1
r=1	13.2935	10.4526	
r=2	2.8409	2.809	
Tonga			
r=0	46.5335***	36.4347***	1
r=1	10.0988	7.4433	
r=2	2.6555	2.6555	
Vanuatu			
r=0	32.8028**	22.7941**	1
r=1	10.0087	7.2056	
r=2	2.8030	2.8030	

Notes:
The critical values for the trace test at the 95% significance level are 29.68 (r=0); 15.41 (r=1); 3.76 (r=2). 35.65 (r=0); 20.04 (r=1); 6.65 (r=2) at 99%.
The critical values for the maximum eigenvalue test at the 95% significance level are 20.97 (r=0); 14.07 (r=1); 3.76 (r=2). 25.52 (r=0); 18.63 (r=1); 6.65 (r=2) at 99%.
The asterisks ** and *** indicate significance at the 5 and 1 percent levels, respectively.

The intercept is included in the estimation to avoid the measurement errors. The test statistics significantly reject the null hypothesis of no co-integration among the exchange rate, domestic and foreign prices in all PICs. These results support the long-run PPP hypothesis for the individual PICs. We apply the likelihood ratio test (Johansen, 1995) to examine the validity of the joint symmetry and proportionality restriction, namely $\beta_1 = 1 \cap \beta_2 = -1$. This indicates that one of the co-integrating vectors is (1, –1, 1). The results are reported in Table A6 (first two columns).

Table A6

Johansen Multivariate Co-integration Test: LR-test

Country	Joint Symmetry and Proportionality Restriction (β1=1 β2=–1)	Joint Symmetry Restriction (β1=-β2)
Fiji	8.341*** [0.0005]	9.112*** [0.0035]
Samoa	24.0094*** [0.0001]	4.0242** [0.0448]
Solomon Islands	13.0511*** [0.0014]	6.4405** [0.0111]
Tonga	10.378*** [0.0055]	3.8557** [0.0495]
Vanuatu	5.9823 *[0.0502]	0.0562 [0.8125]

Notes:
Numbers in brackets are p-values.
The asterisks *, ** and *** indicate significance at the 10, 5 and 1 percent levels, respectively.

We reject the joint symmetry and proportionality restrictions for all PICs. The finding on the rejection of these conditions suggests that the joint symmetry and proportionality restriction may be too restrictive. Our finding is consistent with some studies that apply time series co-integration tests such as Cheung and Lai (1993).

We also examine the validity of the symmetry condition, $\beta_1 = -\beta_2$. The results are reported in Table A6 (last two columns). We are able to reject the null hypothesis which relates to the existence of joint symmetry and proportionality restrictions for Fiji, Samoa, Solomon Islands Tonga and Vanuatu. Although our results suggest that domestic and foreign prices are crucial determinants of the exchange rate in the long run in all PICs, the estimates do not necessarily comply with the restrictive conditions (joint symmetry and proportionality restrictions) imposed by the strong PPP theory in regard to Fiji, Samoa, Solomon Islands, Tonga and Vanuatu.

In conclusion, our evidence tends to support only the weak form of the long-run PPP relationship in PICs.