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PURCHASING POWER PARITY THEORY AND ITS VALIDITY IN PACIFIC ISLAND COUNTRIES

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Abstract.

Among the 14 Pacific island countries (PICs), which are members of the inter-governmental organization known as Pacific Islands Forum, six countries have independent currencies five of them, namely Fiji, Samoa, Solomon Islands, Tonga and Vanuatu have fixed exchange rate regimes and the sixth country 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 in regard to five countries under fixed exchange rate regimes. Our findings show that long-run PPP hypothesis hold for all five PICs.

Keywords: Purchasing Power Parity, Panel cointegration tests, Symmetry, Proportionality, Pacific Island Countries

JEL classification: F31, C23, C52

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I. Introduction

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

However, empirical studies done in respect of both developed and developing countries at different times and for different periods have shown that the PPP theory has little predictive power in the short run, despite the fact that theory provides some guidance to movement in the exchange rates over a period. That is, policy makers are aware that in the long-run if a given country's price level has been rising relatively higher level to that of another country's price level, its currency depreciates.

Amongst the 14 Pacific island countries, six of them have independent currencies. While Fiji, Samoa, Solomon Islands, Tonga and Vanuatu have fixed exchange rate regimes, Papua New Guinea has a floating system since 1994. 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 are pegged to a basket of currencies for past two decades of more, whereas the exchange rate of Solomon Islands which was pegged to United States (US) dollar currency is now pegged to a basket of currencies since September 2012 to a basket of trading partner currencies with US dollar having the largest proportion.

This paper examines the validity of PPP theory in regard to the exchange rates of five countries, 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 theoretical view of the PPP hypothesis, whereas the third section outlines the methodology adopted and discusses the data employed for the analysis. The fourth section reports the results and the final section presents a summary with a set of conclusions with policy implications.

II.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), Anorou *et al* (2005) note that deviations from PPP do occur in the short-run. These are evidenced in studies notably by Dornbusch (1980) and Frenkel (1978). However, not all studies focusing on the long run validity of PPP theory had come out with unanimous results. While for example, Abuaf and Jorian (1990) and Meef and Rogoff (1988), found evidence of PPP theory is holding in the long run, Cooper (1994) and Ahking (1997) obtained evidence to the contrary.

Anorou *et al* (2005) note that the turning point in the investigation, 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 changes in nominal exchange rate are likely to be permanent, the long run PPP theory could be confirmed only if the existence 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 Sims tests, Ahking (1997) used Bayesian unit root approach. Huang and Yang (1996) employed Engle and Granger (1987) two-step approach and Johansen (1988) maximum likelihood procedure as well as Monte-Carlo simulations and obtained different results. Lee (1999) used a generalised error correction model for 13 Asia pacific 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.

III. Methodology and Data

Modelling: PPP Relationship

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

$$r_t = \beta_0 + \beta_1 p_t + \beta_2 p_t^* \qquad (1)$$

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 cointegration 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.

$$r_t = \beta_0 + \beta(p_t - p_t^*) \qquad (2)$$

Since we impose the symmetry condition in Equation (2), this equation can only have a single cointegrating 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.

Panel cointegration tests for testing PPP Hypothesis

Assuming that $\{y_t, x_t\}$ are integrated of order one, I(1) and we consider the following time series model:

$$y_t = \alpha + \beta x_t^{'} + u_t \qquad (3)$$

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

Equation (3) can be estimated by applying single equation and or system techniques. In this study, we shall first estimate it 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 cointegration. Based on this framework, Pedroni develops seven panel cointegration 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

$$k = \frac{k_{N,T} - u\sqrt{N}}{\sqrt{\nu}} \Rightarrow N(0,1) \qquad (4)$$

where $k_{N,T}$ is the panel cointegration statistic and u and ν 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, we adopt the panel group mean Fully Modified OLS following the work by Pedroni (2000). The FMOLS procedure is able to accommodate the heterogeneity problem that is normally present in the transitional serial correlation dynamics and in the long run cointegrating relationships.

We consider the following panel data models:

$$y_{it} = \alpha_i + \beta_i x_{it}^{'} + u_{it} \qquad (5)$$

$$x_{it} = x_{i,t-1}^{'} + e_{it} \qquad (6)$$

Where

$i = 1,2,...,N$ countries over the period of $i = 1,2,...,M$. 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

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

where

$y_{it}^* = (y_{it} - \bar{y}) - \frac{\hat{L}_{21i}}{\hat{L}_{22i}} \Delta x_{it}$ 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

$$t_{\hat{\beta}_{FM}^*} = N^{-1/2} \sum_{i=1}^{N} t_{\hat{\beta}_{FM,i}^*} \text{ where } t_{\hat{\beta}_{FM}^*} = \left(\hat{\beta}_{FM,i}^* - \beta_0 \right) \left(\hat{\Omega}_{11i}^{-1} \sum_{t=1}^{T} (x_{it} - x_i)^2 \right) 1/2$$

After obtaining the estimates, we shall normalize the equation with respect to y_t as we intend to focus only on a single cointegrating vector, that is β' is unique.

Data

The data employed for the study are quarterly data 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 *International Financial Statistics*, an International Monetary Fund publication (IMF 2012).

IV Empirical Results

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, Lin and Chu (2002), Im et al. (1997) and Maddala and Wu (1999). These panel unit root tests are more superior than univariate time series tests (ADF and PP tests). The test proposed by Levin, Lin and Chu (2002), with 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, p. 234).

As shown in Table 2, we could reject the unit root null of exchange rate, domestic price (*p*) and foreign price (*p**) at first difference. This non-stationarity of exchange rates is not surprising because a time trend would not be consistent with long-term PPP (Papell, 1997). Hence, 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).

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) cointegration tests. The results are shown in Table 3. The null hypothesis of no cointegration is rejected by four within-dimension panel cointegration statistics and by three between-dimension panel cointegration statistics provided by Pedroni (1999). Hence, we conclude that both exchange rate, domestic and foreign prices are cointegrated. The validity of PPP hypothesis is further confirmed by the Johansen Fisher panel cointegration test, as shown in Table 4.

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 5. 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 also significant in all countries at least at 5% significance level. Therefore, the findings from both the Pedroni and Johansen Fisher panel cointegration tests supports the presence of a long-run relationship among the exchange rate, domestic and foreign prices for five Pacific Island Countries (PICs).

Since the results of both Pedroni and Johansen Fisher panel cointegration tests favour the weak PPP hypothesis, which are in contrast with the findings for the PPP reported by few 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 cointegration test to individual PICs.

The trace and maximum eigenvalue test statistics are exhibited in Table 6. The intercept is included in the estimation to avoid the measurement errors as in Equation (1). The test statistics significantly reject the null hypothesis of no cointegration 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 cointegrating vectors is (1, −1, 1). The results are reported in Table 7 (first two colums).

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 applying time series cointegration tests such as Cheung and Lai (1993).

We also examined the validity of the symmetry condition, $\beta_1 = -\beta_2$. The results are reported in Table 7 (last two columns). We are able to reject the null hypothesis which is the existence of joint symmetry and proportionality restrictions for PPP 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 and Tonga and Vanuatu. In conclusion, our evidence tends to support only the weak form of the long-run PPP relationship in PICs.

V Summary and Conclusions

This study examines the validity of PPP theory in 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 PPP hypothesis in all these PICs by using different econometric techniques such as panel unit root tests, Pendroni's and Johansen's panel cointegration tests. Using Johansen's likelihood ratio tests, it is found that the joint symmetry and proportionality restrictions are significantly rejected in all the countries. Although our findings provide only weak evidence concerning PPP, the governments will do well to stabilize domestic prices by monitoring high inflation rates and enhancing export competitiveness.

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Table 1: Pacific Island Countries: Nominal Exchange Rates and Inflation

Year	Nominal Exchange Rates				Annual change in price level in percent					
	F$/USD	Tala/US$	Sol $/USD	Ton$/USD	Vat/US$	Fiji	Samoa	Sol Is	Tonga	Vanutau
1981-1990(Ave)	1.25306	1.89	1.64	1.23	104.21	7.3	14.7	16.9	12.75	7.26
1991-2000 (Ave)	1.6328	2.67	3.76	1.4	119.7	3.2	4.1	13.76	3.5	2.62
2001-2005 (Ave)	1.96	3.06	6.91	2.08	125.55	2.1	5.6	7.6	9.62	1.56
2006	1.73	2.78	7.61	2.03	110.64	2.5	3.7	11.22	6.44	2.04
2007	1.61	2.62	7.65	1.97	102.44	4.8	5.6	7.7	5.89	3.96
2008	1.59	2.64	7.75	1.94	101.33	7.7	11.5	17.3	10.44	4.83
2009	1.96	2.73	8.06	2.03	106.74	3.7	6.2	7.1	1.4	4.25
2010	1.92	2.48	8.06	1.91	96.91	5.5	1.1	1	3.54	2.8
2011	1.79	2.32	7.64	1.73	92.61	-	-	-	-	-

Source: IMF (2012).

Table 2A: 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 3: Pedroni residual cointegration test results

Test Statistics	
Panel cointegration statistics (within-dimension)[a]	
Panel ρ-statistic	2.0020** [0.0226]
Panel PP type *ρ*-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 cointegration statistics (between-dimension)[b]	
Group PP type *ρ*-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 cointegration tests, which allow for heterogeneity of parameters across countries.
*, ** and *** Significant at the 10, 5 and 1 percent levels, respectively.

Table 4: Johansen Fisher panel cointegration test results (Lag 2)

Hypothesized No. of CE(s)	Unrestricted Cointegration Rank Test Fisher Statistics			
	Trace Test	**Probability[a]**	**Maximum Eigenvalue Test**	**Probability[a]**
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:
[a] Probabilities are computed using asymptotic Chi-square distribution.
** and *** Significant at the 5 and 1 percent levels, respectively.

Table 5: Pendroni's fully modified OLS estimates

	Intercept (β_0)	**Domestic Price,** $\boldsymbol{p}$ (β_1)	**Foreign Price,** $\boldsymbol{p^*}$ (β_2)
Fiji	2.0104** (2.2511)	1.2253*** (2.8919)	-1.0949*** (-14.855)
Samoa	3.0057*** (2.8428)	1.3710*** (3.4724)	-2.1804*** (-5.0629)
Solomon Islands	2.4291*** (5.3163)	0.8390*** (5.3561)	-2.1051** (-1.9768)
Tonga	4.1544*** (3.9434)	1.1574*** (3.6051)	-0.9456*** (-3.7447)
Vanuatu	6.0711*** (3.5947)	1.3711** (1.9744)	-0.9162*** (-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. ** and *** Significant at the 5 and 1 percent levels, respectively.

Table 6: Johansen multivariate cointegration 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	2.8409	
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	

Note:
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%.
** and *** Significant at the 5 and 1 percent levels, respectively.

Table 7: Johansen multivariate cointegration test: LR-test

Country	Joint Symmetry and Proportionality Restriction ($\beta1=1\cap\beta2=-1$)	Joint Symmetry Restriction ($\beta1=-\beta2$)
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. *, ** and *** Significant at the 10, 5 and 1 percent levels, respectively.