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A TEST OF PURCHASING POWER PARITY: ASIA PACIFIC AND LATIN AMERICA

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ABSTRACT

Finding evidence of the theoretical relationship between exchange rate and inflation has been a difficult proposition in an exchange rate market, despite many studies in developed markets. Three recent papers employing a new research design, Theil's Divisia index method, found that this relationship holds only in the long run, given the sticky price hypothesis. However, this relationship has not yet been tested for economic regions with close trading networks. The use of this method enables us to resolve a longstanding issue as to the veracity of Purchasing Power Parity (PPP). This paper presents results that suggest long-run equilibria in two close trading regions, within both developed and emerging economies. We believe that these findings on long-run equilibrium and the length of time to equilibrium will enrich the literature on exchange rate market behaviour in both developed and emerging markets.

Keywords: exchange rates, purchasing power parity, divisia index, JEL classification: C43, F31

INTRODUCTION

Empirical evidence on exchange rate movements using Purchasing Power Parity (PPP) has been mixed, and it is period-specific as well as country-specific. Studies by Abuaf and Jorion (1990), Lothian and Taylor (1996, 2000, 2008), Taylor (2009), MacDonald and Ricci (2001), Kuo and Mikkola (2001) and Xu (2004) demonstrated that PPP holds in the long-run. Others, including Bayoumi and MacDonald (1999) and Engel (2000), found no evidence or, at best, evidence of only a weak relationship between prices and exchange rates. An assessment of the vast literature on PPP also distinguishes three different approaches in research designs. Early research designs on PPP include tests of correlation to show whether PPP holds as a central tendency for exchange rates. Later, such tests involve time series unit root tests where exchange rate is considered to follow a random walk. The third phase consists of co-integration analysis to test for a long-run equilibrium relationship. One major drawback of long horizon PPP literature is the problem of survivorship bias. Also, previous analyses have often studied only the world's most developed countries and have ignored newly developed countries.

Since developing countries are where relative prices of goods have changed dramatically and where long-run PPP is not likely to hold, the intention of this study is to investigate these developing countries in comparison with developed ones using a new approach that identifies groups of closely trading countries as regions. The dynamics of exchange rates suggest that PPP should be tested within a group of countries with close trading activities, not as a bilateral equilibrium between pairs of countries as previous research has done. Further, Theil's Divisia index method enables a researcher to estimate the symmetric relationship between variables in successive periods and provides a consistent method for aggregation and testing. This paper offers a modest step towards overcoming the shortcomings in current research on exchange rate market dynamics. Two specific objectives of this study are to (i) establish the long-run pricing of currencies within regions and (ii) measure the length of time to equilibrium under price parity and sticky price hypotheses.

The remainder of this paper is divided into five sections. The next section contains a brief overview of the current literature relevant to this study. Section three describes the Divisia methodology, followed by a presentation of the findings in section four. The paper ends with a conclusion in section five.

LITERATURE ON PURCHASING POWER PARITY

The purchasing price parity (PPP) theorem of exchange rates was first established by Cassel (1918).[1] This theory has been extensively tested by many renowned scholars using data mostly from the developed world. PPP has been viewed by many as a basis for international comparisons of incomes and expenditures, which is an equilibrium condition; it is also seen as an efficient arbitrage condition in goods as a theory of exchange rate determination. PPP established a common ground for cross-country comparisons by linking currencies of different countries to price levels or, more precisely, price differences across countries.

The underlying theory of PPP is based on a simple goods market arbitrage argument: ignoring tariffs and transportation costs and assuming common goods consumed should ensure identical prices across countries, under the *law of one price*. While this notion appears simple enough, specifying comparative prices between two countries in the short-run is difficult. This difficulty has led to a majority of the empirical literature failing to verify that PPP holds.[2] Most empirical tests do not attempt to compare an identical basket of goods but instead use different countries' Consumer Price Indices (CPI) or, lately, Producer Price Indices (PPI) to represent goods' prices, and those goods then have varying weights and proportions across countries.

The relative version of PPP suggests that if a country's inflation rate is higher than that of its trading partner, that country will find its currency value falling in proportion to its relative price level increases. The exchange rate *E* adjusts by *k* as a function of P^d domestic prices and P^f foreign prices.

$$E = k\left(\frac{P^d}{P^f}\right) \tag{1}$$

The log is taken on both sides to study changes in exchange rates and arrive at a testable proposition, where *j* represents country, *t* represents time period, *P* represents prices, *d* domestic and *f* foreign as stated below:

$$lnE_{jt} = a_j + b_j ln\left(\frac{P_t^d}{P_t^f}\right)_j + \mu_{jt} \tag{2}$$

Much of the latest literature on establishing parity theorems provides evidence for the theory using relative PPP. These studies implicitly expect that relative PPP will hold across countries with very different inflation rates.

Two major problems with PPP are that it is more likely to hold for traded goods than for non-traded goods[3] and that some prices do not respond immediately because of slow clearing in the goods market due to sticky prices.[4] Overall, PPP is not a causal relationship but an equilibrium condition that must be satisfied in the longer term, an idea that gained empirical verification only in the late 1990s.

When more currencies started to float or under basket management in late 1973, it was commonly assumed that exchange rates would quickly adjust to changes in relative price levels.[5] With the already known failure of PPP holding in the short-run and years of high exchange rate volatility, it seemed that the theory of PPP had also failed to hold during the 1970s and 1980s.[6] The apparent lack of evidence to support this theory at the time acted as a motivating force that led to the development of sticky price, given evidence of a Philips curve on over-shooting exchange rates by Dornbusch (1976). Moreover, in the last two decades, unit root tests for PPP have been shown to have low power, and so researchers often failed to reject the null hypothesis of the random walk.[7]

In their survey of PPP literature, Froot and Rogoff (1994) concluded that PPP is not a short-run relationship and that prices do not offset exchange rate swings on a monthly or even annual basis. Frankel and Rose (1996) examined PPP using a panel of 150 countries for 45 years and confirmed that PPP holds. Their estimate suggested that PPP deviations have a half-life of four years. A study by Manzur (1990) that introduced a new approach, Divisia index numbers, tested PPP for both long-and short-run equilibrium among G7 countries as a group. The short run results vindicated the literature, whereas the long-run results were consistent with the PPP hypothesis and supported the sticky price explanation. His results also identified the length of the long run to be about five years for the group of seven (G7).

Manzur and Ariff (1995) tested PPP for five ASEAN countries in a region and found that purchasing power parity holds well in the long-run for these developing countries but not in the short-run. Their paper reported a shorter time to equilibrium for these developing countries, whose goods prices are less sticky than those of developed countries. A similar test using the cointegration approach failed to reveal equilibrium in the long-run for the same countries. This result was due to both the power of the method used and to the tests being done on an individual country basis despite the ASEAN countries' formation of a closely trading group (Baharumshah and Ariff, 1997). A recent study by Ho and Ariff (2008) confirmed that the long-run equilibrium for a group of Asia Pacific countries is five years. At last, the good news is that there seems to be convergence among the parity theorems in the long-run. However, further work should be done to refine and extend existing knowledge.

DIVISIA INDEX METHODOLOGY

The Divisia index is an appropriate technique for testing PPP since it enables a closely trading group of countries to be treated as a unit in studies of exchange rate dynamics in the financial markets through trading activities. This method requires the construction of an index of variables using the size of countries' respective economies as weights to represent the relationships within a group of *trade intensive* countries. Theil's (1967) well-known methodology of Divisia moments of prices and quantities provides a good indexing method for joint tests to be carried out since exchange rates of closely trading countries are more likely to be jointly determined. This method incorporates the experiences of *closely* *trading* currencies with the prices of traded goods as determined by the exchange of goods, rather than taking pairs of countries in isolation. Divisia parameters, or moments, estimate the symmetric relationship in successive periods and provide a consistent method for aggregation and testing. This approach provides a test for each observation in the sample period, whereas a regression method tests the data for an entire period. A comprehensive discussion of the Divisia Index methodology is detailed in Appendix A.

FINDINGS

Results with Long Run Data

The results to be discussed in this section pertain to two trade-related regions: (i) the Asia Pacific region consisting of Australia, Indonesia, Japan, Korea, Malaysia, Philippines, Singapore and Thailand and (ii) the developing Latin America region consisting of Argentina, Chile, Colombia, Ecuador, Mexico, Peru and Venezuela.[8]

The data series are comprised of quarterly and yearly interval data (see summary in Table 1). These data relate to exchange rates between individual countries, with the United States (US) dollar (as reported in IFS, line rf) as the foreign unit observed at the end of observation periods.[9] The International Financial Statistics (IFS) CD-ROM published by the International Monetary Fund (IMF) is the major data source for this study. Price variables include the Consumer Price Index (CPI) (IFS, line 64) and the Producer (or, Wholesale) Price Index (PPI) (IFS, line 63) for individual countries. Nominal gross domestic product (GDP) (IFS, line 99B) is used for the GDP weights.[10]

Table 1
Data length for the regions of countries.

Region No. of countries	Asia Pacific 8	Latin America 7
Quarterly	1974:1 – 2006:1	1991:1 – 2006:1
Yearly	1974 – 2005	1991 – 2005

Notes: The study includes countries in two trade-related regions with: eight countries in the Asia Pacific region for 32 years and seven countries in the Latin America region for 15 years.

The proxy for domestic prices for each country ($p_t^{'}$) is measured by wholesale prices whenever they are available, or else by consumer prices. For weights ($\overline{w}_i$), we use the individual country's average proportion of GDP in the region. Tables 2 and 3 provide averages over a period of nearly three decades for the Asia Pacific region and more than one decade for the Latin America region. These data can be used to analyse long-run relationships between exchange rates and prices for each of the two regions. Since PPP implies that changes in exchange rates should correspond to changes in inflation differentials, columns (2) and (4) of Tables 2 and 3 show that these two variables are rather closely related in the different regions.

For mixed development countries in the Asia Pacific region, in columns (2) and (4) of Table 2, changes in exchange rates and inflation differentials are almost always very closely linked with matching direction of change. This data set shows that Japan and Singapore have lower inflation rates and therefore, experience appreciation in their respective exchange rates relative to the US dollar. There is evidence of a relationship between exchange rates and relative inflation differentials for this mixed region of countries.

Table 2
Summary Statistics of Yearly Exchange Rate and Inflation Changes with Proportion of GDP for Asia Pacific, 1974 – 2005.

Asia Pacific	Average Exchange Rate ln change $D\bar{s}_i \times 100$	Average Price ln change $D\bar{p}_i \times 100$	Average Inflation Differential ln change $(D\bar{p}_i - D\bar{p}_1) \times 100$	Mean GDP share $\bar{w} \times 100$
(1)	(2)	(3)	(4)	(5)
Australia	0.1145	0.2809	0.0940	8.4324
Indonesia	0.5027	0.6332	0.4464	3.0603
Japan	–0.1604	0.0605	–0.1266	76.8287
Korea	0.1832	0.3456	0.1586	5.8113
Malaysia	0.0734	0.1888	0.0018	1.3396
Philippines	0.3519	0.5324	0.3454	1.3982
Singapore	–0.0638	0.1358	–0.0514	1.0004
Thailand	0.1108	0.2502	0.0632	2.1306
US		0.1870		

Notes: The total number of observations for each country in the region is 32 years. Column (2) is the natural log change of exchange rates, while column (3) is the natural log change in domestic currency prices. Column (4) measures the difference between domestic currency prices and US dollar prices and column (5) indicates the average GDP weights of individual country in the region.

For the region of Latin America, it is surprising to note that the relationship between price differentials and exchange rate changes is mostly positive as can be seen in Table 3. However, since all of these countries have relatively higher inflation rates than the US, their exchange rates have all depreciated relative to the US dollar. The most influential country with the largest average GDP weight is Mexico, followed by Argentina. It is interesting to note that for Argentina, changes in exchange rates outweigh relative inflation differentials compared to the other countries. This phenomenon is probably due to Argentina's major currency crises in the 1990s. Overall, there exists a relationship between changes in price and exchange rates in this region.

Table 3
Summary Statistics of Yearly Exchange Rate and Inflation Changes with Proportion of GDP for Latin America, 1991 – 2005.

Latin America	Average Exchange Rate ln change $D\overline{s}_i \times 100$	Average Price ln change $D\overline{p}_i \times 100$	Average Inflation Differential ln change $(D\overline{p}_i - D\overline{p}_1) \times 100$	Mean GDP share $\overline{w} \times 100$
(1)	(2)	(3)	(4)	(5)
Argentina	0.5342	0.2074	0.1324	26.2031
Chile	0.1650	0.3034	0.2285	8.3810
Colombia	0.5546	0.6073	0.5324	9.5026
Ecuador	1.2522	1.4250	1.3502	2.9726
Mexico	0.6426	0.6838	0.6088	52.8004
Peru	0.2358	0.3035	0.2286	0.0060
Venezuela	1.3584	1.6892	1.6142	0.1344
US		0.0752		

Notes: The total number of observations for each country in the region is 15 years. Column (2) is the natural log change of exchange rates, while column (3) is the natural log change in domestic currency prices. Column (4) measures the difference between domestic currency prices and US dollar prices and column (5) indicates the average GDP weights of individual country in the region.

This relationship can be more clearly observed in scatter plots of the changes in exchange rates against inflation differentials; see Figures 1 and 2. The mixed developed and developing countries region of Asia Pacific reveals a very symmetrical relationship, with all points being relatively close to the 45 degree line. This pattern shows that inflation differentials and changes in exchange rates are very closely correlated, as depicted in vintage textbook graphs of theoretical prediction. The observations in Figure 2 for the Latin America region are similar to those of the other region.

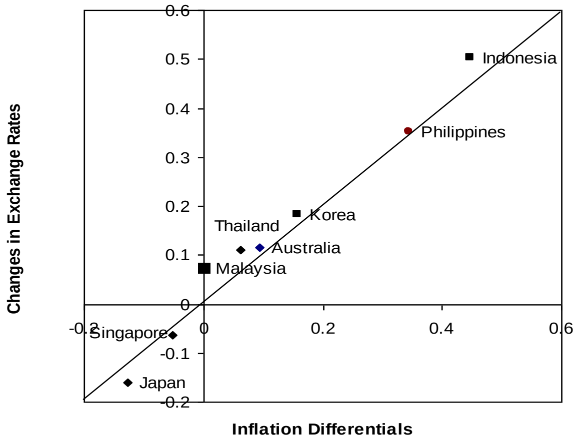

Figure 1. Changes in Exchange Rates and Inflation Differentials for Asia Pacific Region.

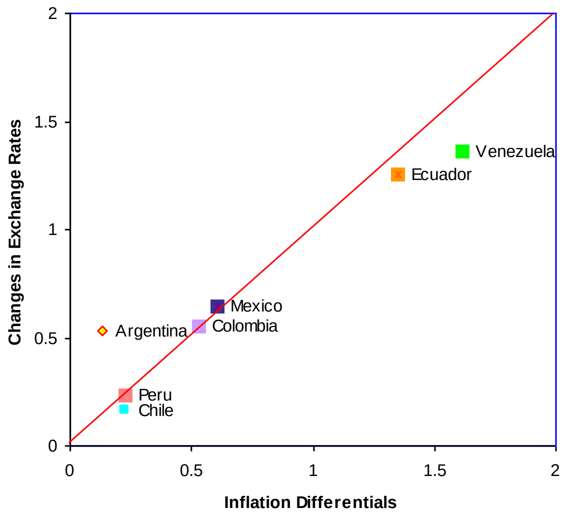

Figure 2. Changes in Exchange Rates and Inflation Differentials for Latin America Region.

The statistics of Divisia moments for price and exchange rate variables are presented in Table 4. The Divisia index for exchange rates, DS, is given in row (1). This index is the average of the sum of all the countries' weighted averages of log changes in exchange rates ($\overline{w}_{it} Ds_{it}$) as in the first set of Tables 2 and 3 but adjusted according to the country weights. A similar procedure is carried out for the other long-run data measures. Divisia indices for prices in both domestic currencies and US dollars are in rows (2) and (3), respectively. Divisia variances of exchange rates and prices are given in rows (4) to (6), and the domestic currency price-exchange rate covariance and its corresponding correlation coefficients are presented in rows (7) and (8), respectively.

Table 4
Divisia Moments of Exchange Rates and Prices for the Regions: Long Run Data

				Asia Pacific (1)	Latin America (2)
(1)	Exchange rate		*DS*	0.02818	1.25738
(2)	Price Index	Domestic currencies	*DP'*	1.17589	1.42638
(3)		$ US	*DP*	1.14770	0.16900
(4)	Variance of	Exchange rate	V^{SS}	1.49433	0.15314
(5)		Domestic currency prices	$V^{P'P'}$	1.08674	0.28488
(6)		US $ prices	V^{PP}	0.04195	0.05744
(7)	Price-exchange rate	Covariance	$V^{P'S}$	1.26956	0.19029
(8)		Correlation coefficient	$C^{P'S}$	0.99624	0.91104

Notes: Divisia indices in the long run for log-changes in exchange rates is in row (1), indices for price changes in domestic currencies in row (2) and for US dollar price changes is in row (3). The corresponding second-order moments and Divisia variances for exchange rates is in row (4), domestic currency prices in row (5) and US dollar prices in row (6). The measurement of co-movement in prices and exchange rates are price-exchange rate covariance in row (7) and their correlation coefficient in row (8). PPP in the long run for the two regions of countries is achieved when the correlation coefficient for domestic currency prices and exchange rates becomes close to unity.

The results from column (1) in Table 4 reveal that long-run Divisia moments for the Asia Pacific countries with a US dollar price variance (V^{pp}) of 0.04 given in row (6) are small in comparison with the other two variances, 1.49 for V^{ss} and 1.08 for $V^{p'p'}$. This finding supports the prediction of PPP where V^{pp} = 0. The variances of exchange rates and domestic currency prices of 1.49 and 1.08, given in rows (4) and (5), are almost equal. Again, these findings are in accordance with the implications of PPP, which confirms that relative inflation deviation is close to zero and the variance of a country's exchange rate should be almost equal to the variance in domestic currency prices (Equation A14). Moreover, the value of the domestic currency price-exchange rate covariance of 1.27 in row (7) is also almost equal to the domestic currency price and exchange rate variances in row (5). Finally, the value of the domestic currency price-exchange rate correlation coefficient is 0.99 in the long-run. This coefficient is obviously close to unity, which is implied by PPP (Equation A16).

Similarly, for the region of Latin American countries in column (2), the long-run Divisia moments US dollar price variance (V^{pp}) of 0.06 given in row (6) is small relative to the other two variances of 0.15 for V^{ss} and 0.28 for $V^{p'p'}$. This result is supportive of the PPP prediction where V^{pp} = 0 (Equation A15).

The covariance of domestic currency price-exchange rate (0.19) is also close to the domestic currency price variance of 0.28. The value of the domestic currency price-exchange rate correlation coefficient is 0.91 for the long-run, and this is again close to unity and thus, consistent with PPP. In summary, long-run data results for the mixed developed and developing countries regions are consistent with the PPP hypothesis.

Results with Short Run Data

To provide a clear comparison with the existing literature, we also derive results for the short run equilibrium, knowing very well that it is unlikely to hold. There are two reasons for doing this: first, there has been no prior evidence to support an expectation of short-run equilibrium, and second, the tests were done using individual countries, unlike our region-based analysis. Similar to the above section on long-run data, this section applies the Divisia methodology to quarterly data for the two regions. The average changes in prices and exchange rates are summarised in Table 5. Column (1) refers to the mean *n*-country average exchange rate changes, and column (2) is the mean domestic currency average inflation rate. Column (3) provides the mean US inflation rate, and column (4) gives the average Divisia mean of PPP deviations.

The Asia Pacific region's average exchange rates appreciate (relative to US dollars) by about 0.58% per quarter, and domestic currency prices increase by 0.41% on average, with relative prices increasing by 0.91 per cent on average. Similarly, the average deviation from PPP is -0.00576 – 0.00405 + 0.00910 = -0.0007, as in column (4). The Latin America region has an average exchange rate depreciation of about 2.33% per quarter, and domestic currency prices increase by an average of 2.75%. This price increase is much higher than the US relative price increase of 0.29% and results in depreciation of the currency value. Here, there is an average deviation from PPP of 0.02330 – 0.02747 +0.00289 = -0.00128, as in column (4).

Table 5
Divisia Indices of Mean Quarterly Exchange Rates and Prices: Short-Run Data.

	Exchange Rate	Price Index of domestic currencies	US Inflation	Deviations from PPP
	(1)	(2)	(3)	(4)
Region	*DS*	*DP'*	*DP*	*E*
Asia Pacific	–0.00576	0.00405	0.00910	–0.00071
Latin America	0.02330	0.02747	0.00289	–0.00128

Notes: The short run Divisia Index moments for weighted natural logarithm change in: (a) exchange rates in column (1), (b) domestic currency prices in column (2) and (c) US dollar prices in column (3). Column (4) provides the deviations from PPP.

A brief look at the relationship between average exchange rate changes and inflation differentials for the shorter term in Figures 3 and 4 shows almost no relation between exchange rates and prices for these regions in the short run. This finding is consistent with theoretical and empirical beliefs that PPP does not hold well in the short run.

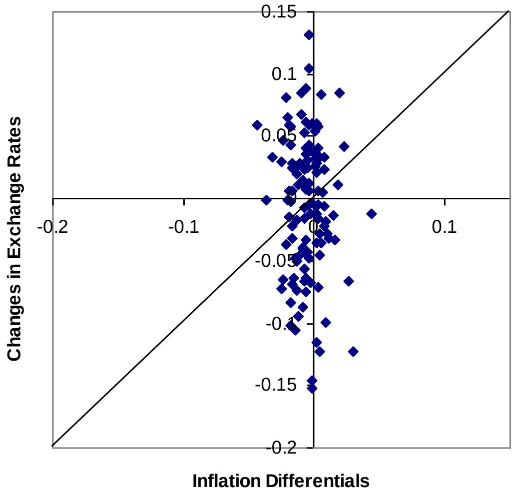

Figure 3. Exchange Rate Changes and Inflation Differentials for Asia Pacific Region in the Short Run

Further investigation into the variances, covariances and correlation coefficients for quarterly data in Table 6 underlines the absence of a short run relation between exchange rates and prices. This table provides mean values of short run quarterly data, analogous to rows (4) to (8) of Table 4. On average, US dollar price variance V^{pp} approximates exchange rate variance V^{ss} instead of becoming zero as predicted by PPP (Equation A15).

It is not surprising to note that the correlation coefficients ($C^{p's}$) for all of the regions are low relative to their long-run figures. The mean price-exchange rate correlation coefficient for Asia Pacific countries is only 0.17 and for the Latin America region, only 0.31. This is very different from unity according to PPP (Equation A16). These results clearly show that short-run changes in exchange rates and prices do not accord with the price parity theory for the three regions in this study. However, the long-run results fell in line with the theory's predictions.

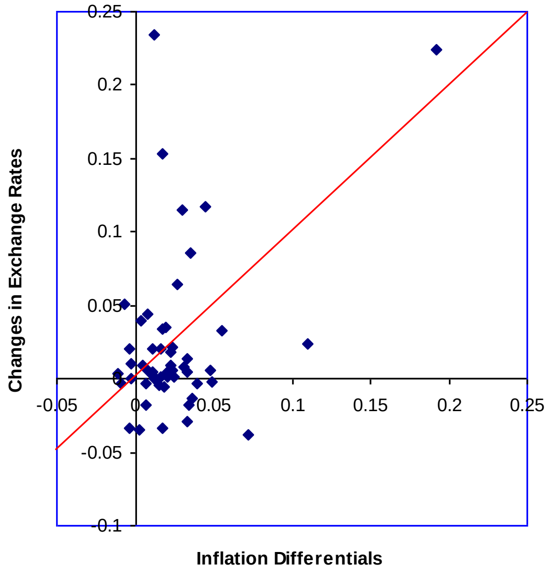

Figure 4. Exchange Rate Changes and Inflation Differentials for Latin America Region in the Short Run

Table 6

Divisia Indices of Mean Quarterly Covariances of Exchange Rates and Prices: Short-Run Data

Region	Variance of			Price –exchange rate	
	Exchange Rate V^{SS}	Domestic-currency prices $V^{P'P'}$	US$ prices V^{PP}	Covariance $V^{P'S}$	Correlation coefficient $C^{P'S}$
	(1)	(2)	(3)	(4)	(5)
Asia Pacific	0.06760	0.00958	0.06660	0.00530	0.17158
Latin America	0.00621	0.00097	0.00514	0.00102	0.31291

Notes: The second-order moments and Divisia variances for: (a) exchange rates in column (1), (b) domestic currency prices in column (2) and (c) US dollar prices in column (3). The measurement of co-movement in prices and exchange rates are price-exchange rate covariance in column (4) and their correlation coefficient in column (5). PPP in the long run for the two regions of countries is achieved when the correlation coefficient for domestic currency prices and exchange rates becomes close to unity.

Time to equilibrium

To investigate the time to equilibrium for PPP in the two regions, multi-period Divisia price and exchange rate correlation statistics are reported in this section. Changes in prices and exchange rates are computed over periods of one year, two years and beyond. Even though previous studies utilised quarterly data, this study prefers yearly data due to their accuracy relative to other time frames. As comparison periods grow further apart, the number of observations diminishes. Results for the two regions are shown in Tables 7 and 8.

The results for the Asia Pacific region are shown in Table 7. Each column in the table provides the respective Divisia moments for the given length of change in each time period. It is interesting to note that corresponding second-order Divisia moments still follow, whereas where variances of US dollar prices tend to be relatively low and variances of exchange rates and domestic currency prices tend to be very close to each other, as explained in an earlier section. For all periods of study, the weighted log-change in exchange rates is almost always equal to the difference between the log-change in domestic prices less the log-change in US dollar prices, which is consistent with the theory (Equation A4).

Note that both the covariance and the correlation coefficient of the domestic price-exchange rate increase as the time period's duration increases, until eventually the correlation coefficient approaches unity.[11] This table shows that long-run PPP in these regions is achieved after five years. Our results are consistent with those of Manzur and Ariff (1995), who produced similar results of four and a half years without accounting for currency fluctuations in the late 1990s.

Table 7
Divisia Indices for Exchange Rates and Prices for Various Changes in Yearly Time Periods: Asia Pacific

				Yearly	2 Yearly	3 Yearly	4 Yearly	5 Yearly
(1)	Exchange rate		DS	–0.01571	–0.03078	–0.04617	–0.07804	–0.07929
(2)	Price Index	Domestic currencies	DP'	0.02497	0.05059	0.07651	0.06845	0.12526
(3)		$ US	DP	0.04068	0.08137	0.12268	0.14649	0.20455
(4)	Variance of	Exchange rate	V^{SS}	0.00606	0.01268	0.01959	0.03557	0.04127

(continued)

Table 7 (*continued*)

				Yearly	2 Yearly	3 Yearly	4 Yearly	5 Yearly
(5)		Domestic currency prices	$V^{P'P'}$	0.00146	0.00484	0.00968	0.01584	0.02270
(6)		US $ prices	V^{PP}	0.00522	0.00748	0.00769	0.01115	0.01305
(7)	Price-exchange rate	Covariance	$V^{P'S}$	0.00115	0.00502	0.01079	0.02013	0.02546
(8)		Correlation coefficient	$C^{P'S}$	0.36140	0.62190	0.70530	0.72350	0.8077

Notes: Divisia indices in the long run for log-changes in exchange rates is in row (1), indices for price changes in domestic currencies in row (2) and for US dollar price changes is in row (3). The corresponding second-order moments and Divisia variances for: (a) exchange rates in row (4), (b) domestic currency prices in row (5) and (c) US dollar prices in row (6). The measurement of co-movement in prices and exchange rates are price-exchange rate covariance in row (7) and their correlation coefficient in row (8). PPP in the long run for the two regions of countries is achieved when the correlation coefficient for domestic currency prices and exchange rates becomes close to unity.

New analyses of the Latin American region of countries, presented in Table 8, found that PPP is only achieved after a longer period, about ten years. This discovery is puzzling: their sticky prices could not be worse than those of the G7 countries, as mentioned in Manzur (1990). Both the covariances and correlation coefficients of domestic price-exchange rate increase at first but then fluctuate between 0.2 and 0.7 for the longer range of time intervals. Since the data for this region range from 1991–2005, a turbulent period for this region of countries, the longer equilibrium for PPP can be attributed to misalignment emanating from the currency crises of the 1990s. Latin America is the region with the longest time to equilibrium in this study, due to large fluctuations in prices and instabilities in countries' exchange rates over this period. Nevertheless, price parity holds even for these crisis-incapacitated countries!

Table 8
Divisia Indices for Exchange Rates and Prices for Various Changes in Yearly Time Periods: Latin America

				Yearly	2 Yearly	3 Yearly	4 Yearly	5 Yearly
(1)	Exchange rate		DS	0.16905	0.34718	0.55752	0.64982	1.19775
(2)	Price Index	Domestic currencies	DP'	0.20174	0.42170	0.52728	0.84092	1.17452
(3)		$ US	DP	0.03269	0.07452	–0.03024	0.19111	-0.02323

(continued)

Table 8 (*continued*)

				Yearly	2 Yearly	3 Yearly	4 Yearly	5 Yearly
(4)	Variance of	Exchange rate	V^{SS}	0.06494	0.13364	0.30122	0.17259	0.11977
(5)		Domestic currency prices	$V^{P'P'}$	0.02200	0.06140	0.06970	0.15949	0.24044
(6)		US $ prices	V^{PP}	0.04267	0.11615	0.13106	0.27576	0.09041
(7)	Price-exchange rate	Covariance	$V^{P'S}$	0.02214	0.03945	0.03609	0.02816	0.13490
(8)		Correlation coefficient	$C^{P'S}$	0.67389	0.44084	0.24908	0.16977	0.79496

Notes: Divisia indices in the long run for log-changes in exchange rates is in row (1), indices for price changes in domestic currencies in row (2) and for US dollar price changes is in row (3). The corresponding second-order moments and Divisia variances for: (a) exchange rates in row (4), (b) domestic currency prices in row (5) and (c) US dollar prices in row (6). The measurement of co-movement in prices and exchange rates are price-exchange rate covariance in row (7) and their correlation coefficient in row (8). PPP in the long run for the two regions of countries is achieved when the correlation coefficient for domestic currency prices and exchange rates becomes close to unity.

In summary, it can be seen that the value of the correlation coefficient initially increases with the length of the change and then stabilises at a value of 0.8 within five years for the Asia Pacific region; stabilisation occurs around the ten-year mark for the Latin America region. Thus, the results tend to identify the time to equilibrium for the different regions at different time. As far as PPP is concerned, this is only an approximate measure of the length of the long-run for each of these two regions of countries.

CONCLUSION

The results reported in this paper are derived by applying Divisia index methodology to test the relative PPP in each of two regions of trade-related countries comprised of both developed and developing countries. The results clearly vindicate the predictions of purchasing power and sticky price hypotheses as well as existing evidence of exchange rate over-shooting. Interestingly, the study provides new evidence to support longer term PPP relationships for these groups of countries, especially for the groups of developing countries that had not previously been studied on even a bilateral basis. As expected, the theory does not hold up in the short-run because of sticky prices, which is consistent with empirical findings. It is also fascinating to note that the broad measures of the length of time to reach long-run equilibrium are approximately five years and ten years for the Asia Pacific and Latin American regions, respectively. This difference in time is consistent with the price dynamics of traded products under sticky prices. The use of the Divisia method enables us to resolve a longstanding issue as to the veracity of the PPP. Using this method, researchers can identify PPP as being a long-run phenomenon. Hence, future studies should adopt such test methods and data parsing to search for long-run equilibrium relationships.

It is interesting to note that PPP models ignore trade and capital flows as well as other country-specific fundamentals. Therefore, future investigations should look at the role of other fundamentals beyond PPP in determining exchange rates. This study looks at PPP alone and provides new findings to suggest that PPP could explain movements in exchange rates in the longer term for regions of countries with different levels of development. We conclude that PPP is still alive, and it takes a different length of time to reach equilibrium.

NOTES

[1] Recent writers have attributed this theory to an earlier origin: Spanish writers in the eighteenth century.

[2] Empirical work that has led to conflicting empirical findings for PPP includes MacDonald (1993), Rogoff (1996), Edison, Gragnon and Melick (1997), Cheng (1999), Edwards and Savastano (1999), Kim (1990), Cheung, Chinn and Pascual (2003) and Bayoumi and MacDonald (1999). They have all found no clear evidence or, at best, a very weak relationship between inflation and exchange rates.

[3] The results of the aggregative method for the law of one price are strongly positive, but these results are more significant for traded goods than for non-traded goods, according to Officer (1986).

[4] The effect of monetary policy on interest rates and exchange rates is significantly affected by the behavior of real output, but in the short-run, lower interest rates can cause the exchange rate to overshoot its long-run depreciation level, according to Dornbusch (1976). He provided the key theoretical response that price inertia could be an important source of large real exchange rate movements.

[5] With the collapse of the Bretton Woods system, countries started to float their exchange rates instead of fixing them to the dollar.

[6] Henry and Olekaln's (2002) study on Australia found little evidence for long-run equilibrium between exchange rate and prices. In a similar view, Adler and Lehman (1983) found that deviations from PPP follow a random walk without reverting to PPP for 43 countries.

[7] MacDonald and Ricci (2001), Kuo and Mikkola (2001), Lothian and Taylor (2000), and Schnabl and Baur (2002) found considerable evidence for a long-run relation and concluded that fundamentals play a significant role in determining exchange rates.

[8] In determining which countries to include, the trade proportions within the region were tabulated, and the countries were selected based on how closely they are linked.

[9] These exchange rate quotations can be expressed in either a unit of foreign currency (Direct quote) or a local unit expressed in foreign equivalent (Indirect quote). A direct exchange rate quotation gives the home currency price of in terms of foreign currency, whereas the indirect quote gives the one unit home currency equivalent in foreign currency. They are actually the reciprocals of one other. To avoid confusion, direct quotations are used in this study, as is the practice in the literature, unless stated otherwise.

[10] A compilation of data used in this study is available upon request.

[11] As mentioned in Manzur (1990) as well as Manzur and Ariff (1995), the long-run cut-off threshold for a correlation coefficient to be considered close to unity is when it is above 0.8.

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APPENDIX A:
Divisia Index Method

Following the specifications in Manzur (1990) and Manzur and Ariff (1995), the Divisia approach can be briefly explained as follows. Assume there are n countries in a test sample. Assume the price levels in these countries in domestic currencies are $p'_1, ..., p'_n$. If the n exchange rates (defined as the domestic currency cost of US$1) are $s_1, ..., s_n$, then these price levels in terms of US dollars are $p_1^{'} / s_1, ..., p_n^{'} / s_n,$. This may be written parsimoniously as $p_1, ..., p_n$. Assume now that a consumer purchases the quantities $q_1, ..., q_n$ from the *n* countries. The cost of this basket of purchases, in U.S. dollars, may be represented as: $p_1 q_1 + ... + p_n q_n = M$. By using a weight, we now represent $w_i = p_i q_i / M$ as the share of *i* in *M*. Writing D for log-change operator ($Dx_t = \log x_t - \log x_{t-1}$), we define the Divisia indices for the *n* countries as:

$$DP_t = \sum_{t=1}^{n} \bar{w}_{it} Dp_{it} \tag{A1}$$

$$DP_t^{'} = \sum_{t=1}^{n} \bar{w}_{it} Dp_{it}^{'} \tag{A2}$$

$$DS_t = \sum_{t=1}^{n} \bar{w}_{it} Ds_{it} \tag{A3}$$

Where $\bar{w}_{it} = (w_{it} + w_{i,t-1}) / 2$ is the arithmetic average of w_{it} in periods *t-1* and *t*. From the three equations above, the Divisia index of world inflation measured in terms of domestic currencies and the weighted average change in the values of the *n* currencies relative to the US dollar is:

$$DP_t = DP_t^{'} - DS_t \tag{A4}$$

This equation states that world inflation measured in terms of dollars (*DP*) equals the corresponding concept measured in terms of the domestic currencies (DP') minus the average depreciation of the *n* currencies. The indices defined above are weighted means of the price and exchange rate log-changes, the weights being the $\bar{w}_{it}$'s. These indices are the weighted first-order Divisia moments of the Dp_i's, $Dp_i^{'}$'s and Ds_i's. The corresponding second-order moments are the Divisia variances:

$$V_t^{PP} = \sum_{i=1}^{n} \bar{w}_{it} (Dp_{it} - DP_t)^2 \tag{A5}$$

$$V_t^{P'P'} = \sum_{i=1}^{n} \bar{w}_{it} (Dp_{it}^{'} - DP_t^{'})^2 \quad \text{and} \tag{A6}$$

$$V_t^{ss} = \sum_{i=1}^{n} \bar{w}_{it} (Ds_{it} - DS_t)^2 \qquad \text{(A7)}$$

These variances measure the degree to which prices and exchange rates vary disproportionately across countries. To measure the co-movement of prices and exchange rates across countries, the associated Divisia price-exchange rate covariances are:

$$V_t^{ps} = \sum_{i=1}^{n} \bar{w}_{it} (Dp_{it} - DP_t)(Ds_{it} - DS_t) \qquad \text{(A8)}$$

$$V_t^{p's} = \sum_{i=1}^{n} \bar{w}_{it} (Dp_{it}^{'} - DP_t^{'})(Ds_{it} - DS_t) \qquad \text{(A9)}$$

while the domestic price-exchange rate correlation coefficient is:

$$C_t = V_t^{p's} / (V_t^{p'p'} \times V_t^{ss})^{1/2} \qquad \text{(A10)}$$

The relative version of PPP can now be restated as the percentage change in the exchange rate equal to the inflation differential:

$$Ds_{it} = Dp_{it}^{'} - Dp_{1t} + e_{it} \qquad \text{(A11)}$$

where Dp_{1t} is inflation in the U.S. and e_{it} is the deviation from PPP. Under PPP, the deviation $e_{it} = 0$ and $V_t^{p'p'} = V_t^{ss} = V_t^{p's}$, $V_t^{pp} = V_t^{ps} = 0$ and $C_t = 1$. Thus:

$$DS_t = DP_t^{'} - Dp_{1t} + E_t \qquad \text{(A12)}$$

where $E_t = \sum_{i=1}^{n} \bar{w}_{it} e_{it}$ is the Divisia mean (or weighted mean) of the deviations from PPP. This equation (A12) states that the *n*-country average change in exchange rate is equal to the difference between the *n*-country average inflation rate in terms of domestic currencies and that in the U.S., plus an average deviation. As PPP implies $e_{it} = E_t = 0$, this means that the *n*-country average inflation rate in dollars (DP) equals inflation in the U.S. (Dp). Therefore,

$$Ds_{it} - DS_t = Dp_{it}^{'} - DP_t^{'} + e_{it} - E_t \qquad \text{(A13)}$$

the change in the *i*th exchange rate relative to *n*-country average equals the deviation of inflation in *i* from the *n*-country average, which is an inflation differential, plus a relative deviation, $e_{it} - E_t$. Note that the Divisia mean of the relative deviations is zero: $\sum_{i=1}^{n} \bar{w}_{it} \; e_{it} - E_t \; = 0$. Also, note that the above equation is definitely true and that under PPP, $e_{it} = E_t = 0$. Also from the above, we can obtain:

$$V_t^{ss} = V_t^{p'p'} = V_t^{p's} \tag{A14}$$

$$V_t^{pp} = V_t^{ps} = 0 \text{, and} \tag{A15}$$

$$\rho_t^{p's} = \frac{V_t^{p's}}{\sqrt{V_t^{p'p'} V_t^{ss}}} = 1 \tag{A16}$$

The strength of the magnitude of the relationship between prices and exchange rates is measured by Equation (A16). Its theoretically-suggested value at equilibrium is equal to one. That is, under PPP, (1) the domestic currency price and exchange rate variances and their covariance all coincide; (2) the variance of US dollar prices and their covariance with exchange rates both vanish; and (3) domestic prices and exchange rates are perfectly correlated under PPP.